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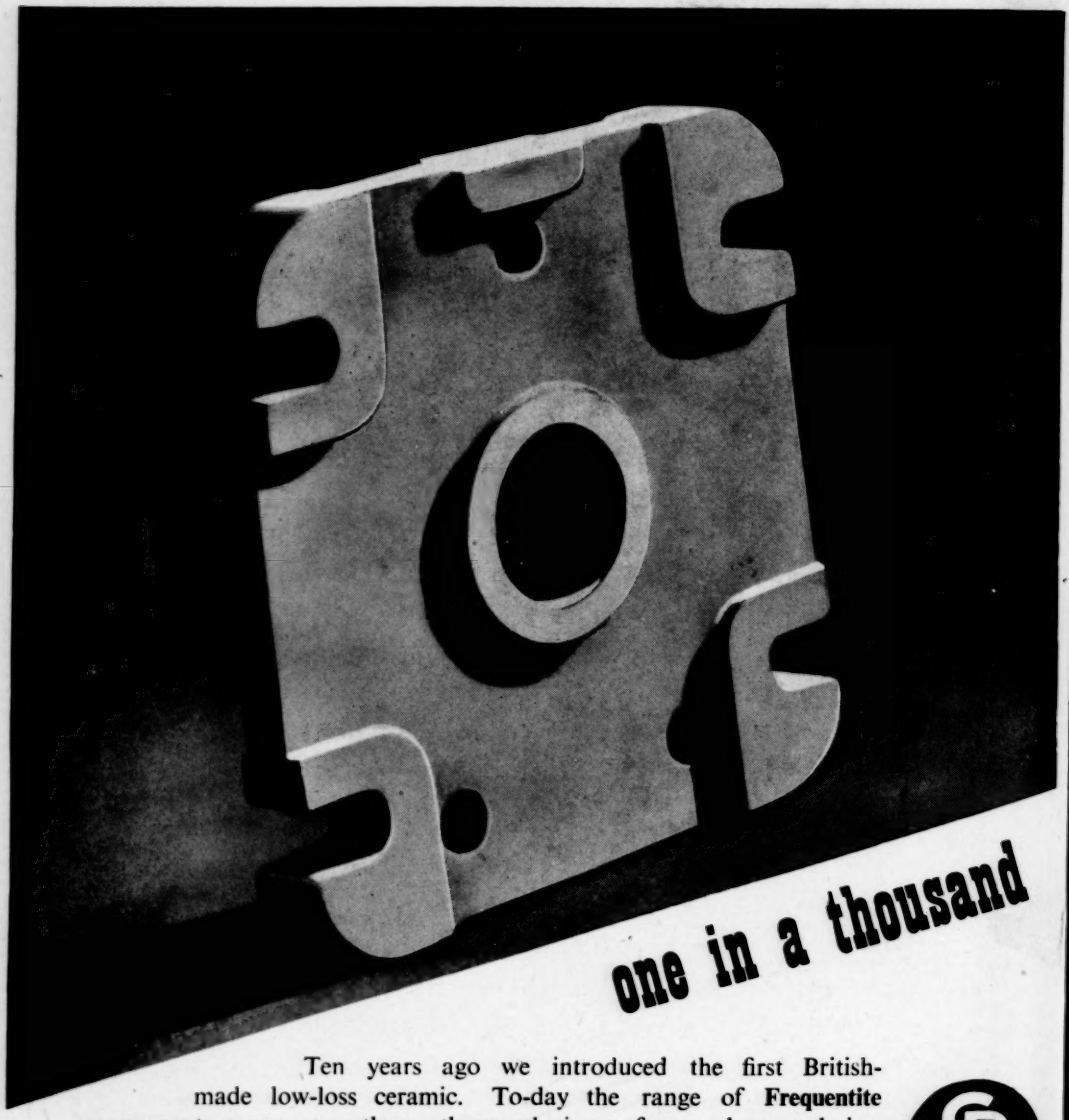

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WIRELESS ENGINEER

Editor HUGH S. POCOCK, M.I.E.E. Technical Editor Prof. G. W. O. HOWE, D.Sc., M.I.E.E.

VOL. XXI JANUARY, 1944 NO. 244

The Effect of the Earth's Magnetic Field in the Ionosphere

IN the last Editorial we considered the transmission of waves through the ionosphere, neglecting the effect of the magnetic field of the earth, and assuming that the damping was negligible. For many purposes the latter assumption is permissible, but the transmission is radically affected by the earth's magnetic field. This subject has been discussed more or less fully in numerous articles and textbooks, but usually in a manner more calculated to appeal to the mathematical physicist than to the radio engineer who wishes to form a clear mental picture of the various phenomena.

If a plane polarised electromagnetic wave has an electric field strength $\mathfrak{E}$ equal to $\hat{\mathfrak{E}} \sin \omega t$ e.s. units, it will exert a force $\mathfrak{E}q$ on each electron, where q, the charge of the electron, is equal to -4.8×10^{-10} e.s. units.

If $s = \hat{s} \sin \omega t$ is the displacement of the electron from its normal position, its acceleration will be $d^2s/dt^2 = -\omega^2 \hat{s} \sin \omega t = -\omega^2 s$, and since force = mass × acceleration $\mathfrak{E}q = -w^2sm$ where $= 9.11 \times 10^{-28}$ gramme. Hence since q is negative s is a positive maximum when $\mathfrak{E}$ is a positive maximum, and $\hat{s} = -\hat{\mathfrak{E}}q/\omega^2 m$. When $\mathfrak{E}$ has its maximum positive value tending to drive the electron in the negative direction, the electron at that moment has its maximum positive displacement. Hence the Maxwellian displacement $\mathfrak{E}/4\pi$ is reduced to $\mathfrak{E}/4\pi + sqN = \frac{\mathfrak{E}}{4\pi}\left(1 - \frac{4\pi Nq^2}{\omega^2 m}\right)$ where q is negative and N is the number of electrons per cm^3. The apparent dielectric constant of the medium is thus reduced to $1 - \frac{4\pi Nq^2}{\omega^2 m}$ which may be written $1 - \omega^2_0/\omega^2$ where ω^2_0 is put for $4\pi Nq^2/m$, which is simply proportional to the electron density N. The greater the electron density the higher must be the frequency to produce a given decrease in κ.

If, however, there is a magnetic field, such as that of the earth, the moving electrons will experience a force at right-angles to their motion. To simplify the problem we shall first assume that the magnetic field H is in the direction of wave propagation, or, in other words, we shall concern ourselves at present only with the component of the magnetic field in this direction. It simplifies the problem to regard the plane polarised wave as the resultant of two circularly polarised waves, that is, to resolve the alternating field $\mathfrak{E}$ into two fields of constant magnitude $\hat{\mathfrak{E}}/2$ rotating in opposite directions. The effects of these two fields can be studied separately and the results then combined. Each rotating field will exert a constant but rotating force $q\hat{\mathfrak{E}}/2$ on each electron. An electron rotating in the plane normal to the field experiences a force due to the magnetic field, radially inwards or outwards depending on its direction of rotation. Its velocity will be ωr where r is the radius of its path, and the force therefore $\omega rqH/3.10^{10}$ dynes. The rotating electron is also subjected to a centrifugal force $m\omega^2 r$ dynes acting radially outwards. These various forces on the rotating electron are shown in Fig. 1, in which the reader is supposed to be looking in the direction of transmission and therefore also along the direction of the magnetic field H. The force f_e is in the opposite direction to $\hat{\mathfrak{E}}/2$ because the charge of the electron is negative, but it is of the same magnitude for both directions of rotation. In the left-hand diagram the electron moving to the left is equivalent to a current element in the reverse direction, and an application of the left-hand rule shows that it will experience an outward force f_m as shown; in the right-hand diagram the force will be in the opposite direction. The forces f_e and f_m are proportional to the radii of the circular path which adjust themselves until $f_c = f_e - f_m$ for the left-hand rotation, and $f_c = f_e + f_m$ for the right-hand

rotation. Substituting the values found for these forces we have $m\omega^2 r = -q\frac{\hat{\mathfrak{E}}}{2} \pm \omega r q H/3.10^{10}$.

Normally an electric force $\hat{\mathfrak{E}}/2$ would produce a displacement $D = \hat{\mathfrak{E}}/8\pi$; it now produces a resultant displacement of $\hat{\mathfrak{E}}/8\pi + qNr$, which, on substituting for r from the above equation, is seen to be equal to $\frac{\hat{\mathfrak{E}}}{8\pi}\left[1 - \frac{4\pi q^2 N}{\omega^2 m \mp \frac{\omega q H}{3.10^{10}}}\right]$.

Hence the effective dielectric constant of the medium is reduced from unity to

$$1 - \frac{4\pi q^2 N/m}{\omega^2 \mp \frac{\omega q H}{3.10^{10} m}}$$

It must be remembered that the charge q of an electron is negative. It is obvious from this

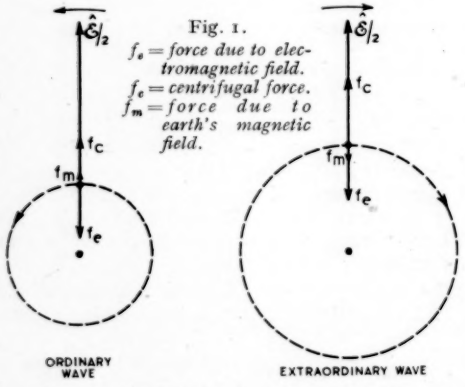


Fig. 1.
f_e = force due to electromagnetic field.
f_c = centrifugal force.
f_m = force due to earth's magnetic field.

expression that all the terms in the fraction have the dimensions of the square of an angular velocity and we can put $\omega^2{}_0$ for $4\pi q^2 N/m$ and ω_m for $-qH/3.10^{10}m$, and thus write

$$\kappa = 1 - \frac{\omega^2{}_0}{\omega^2 \pm \omega\omega_m}$$

Inserting the values of q and m it is found that $\omega^2{}_0 = 3.18 \times 10^9 N$ and $\omega_m = 17.56 \times 10^6 H$; hence $\kappa = 1 - \frac{3.18 \times 10^9 N}{\omega^2 \pm 17.56 \times 10^6 \omega H}$

This formula for κ gives the values of the ratio c^2/v^2, where $c = 3.10^{10}$cm per second and v is the phase velocity of the circularly polarised wave. The positive sign refers to the left-hand and the negative to the right-hand diagram in Fig. 1. If ω_0 and ω_m are small compared with ω, the latter gives the smaller value of κ and therefore the higher phase velocity, as one would expect from Fig. 1.

If in the right-hand diagram the force f_m due to the magnetic field becomes so large that it is equal to the centrifugal force f_c, no electric force f_e would be necessary to maintain the rotation were it not for losses. At this gyroscopic resonant frequency the radius will increase, and with it the velocity of the electrons and the losses due to their collisions with the positive ions and neutral atoms, until these losses are equal to the power which

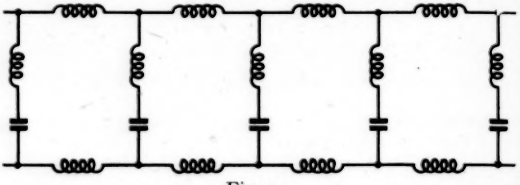


Fig. 2.

can be supplied from the electromagnetic field of the wave. At this frequency the wave will be rapidly damped out or absorbed. It is because of this peculiar behaviour that this right-handed wave is known as the extraordinary wave or ray. The phenomenon is very analogous to what would happen in a transmission line consisting of two conductors having inductance but no resistance, shunted by a number of condensers, but with an inductance in series with each condenser. As the frequency was increased the effective shunt capacitance would be decreased by the coils in series with the condensers, until at a certain frequency the shunt arms would resonate and the current through them would only be limited by the losses occurring in them. The power lost in each shunt would be V^2/R where R was the small effective resistance at resonance. The loss of power, and therefore the attenuation of the wave, would be very great.

The mechanism of the attenuation is very similar in the two cases. The losses affect the phase of the otherwise purely reactive shunt or displacement current, and therefore also of the line current and magnetic field; this in turn affects the phase of the induced e.m.f. and results in an attenuation of the wave.

This phenomenally large absorption occurs when $f_m = f_c$, that is, when $-\frac{\omega r q H}{3.10^{10}} = m\omega^2 r$

and therefore $\omega = \frac{-qH}{3.10^{10}.m} = \omega_m$.

Hence ω_m in the above formula for κ is the magneto-resonant angular velocity. Assuming for the present that H is so small, or the frequency so high, that ω_m is small compared with ω, and that the electron density is so low that $\omega^2{}_0$ is less than ω^2, the two values of κ will lie between 0 and 1 and the phase velocity of both waves will be finite. The

right-handed wave, to which the lower sign refers, will have the smaller κ and therefore the higher phase velocity, but also the greater damping on account of the higher velocity of its electrons and the consequent increased loss by collisions. The two advancing waves are represented by two spirals, one right-handed and the other left-handed, representing the ends of the $\hat{\mathfrak{E}}/2$ vectors, but as the right-handed one has a longer pitch or wavelength, their resultant will gradually rotate, giving, in the absence of damping, a plane-polarised wave with a gradual rotation of the plane of polarisation, as it penetrates into the ionosphere. Owing, however, to one wave being more damped than the other, the two rotating vectors become of different lengths and consequently give a resultant even when they are in opposition, thus converting the plane polarised wave into an elliptically polarised one. If one of the circular component waves were entirely damped out, the other would continue alone as a circularly polarised wave.

If a pulse consisting of a group of radio-frequency oscillations is propagated vertically upwards into the ionosphere, it travels against the downward vertical component of the earth's field in the northern hemisphere, since the so-called north pole of the earth is really a south pole. If it is reflected it travels downwards in the same direction as the field. If it is resolved into the two circular components, Fig. 1 will refer only to the downcoming wave; travelling upwards, it is moving against the direction of the earth's field, and consequently the left-handed component will be the extraordinary one, but on reflection, to anyone travelling with the wave it becomes right-handed and, as it is now travelling with the field, it is still the extraordinary wave.

As the two components of the constituent waves of the group penetrate further into the ionosphere the electron density increases. The extraordinary waves have the higher phase velocity, and consequently the lower group velocity. This difference may be enough to enable the group of ordinary waves to get quite clear ahead of the group of extraordinary waves and produce two separate pulses. If this were the only thing tending to split the pulse into two, the ordinary wave pulse would always be the first to return to the earth. The time spent in the ionosphere depends, however, not only on the speed of the wave but also on the distance it has to travel before it is reflected. The

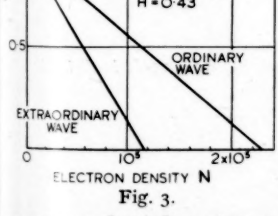


Fig. 3.

formula for κ shows that for the ordinary wave, i.e. using the upper sign, ω^2_0, which is proportional to the electron density N, must reach a higher value in order to reduce κ to zero and with it the group velocity. Hence the extraordinary pulse is reflected and begins the return journey, leaving the faster moving ordinary pulse to penentrate further into the ionosphere until it reaches a region of sufficient electron density to reflect it or, failing that, passes through the layer and is lost.

These conclusions have been fully confirmed by the experimental results obtained by Appleton and the band of workers inspired and guided by him. At night they found that as the frequency was increased from 2 to about 4 Mc/s the ordinary wave was increasingly delayed as compared with the extraordinary wave until the difference corresponded to a difference of height of nearly 150 kilometres. When the frequency reached about 4.25 Mc/s the ordinary wave failed to return, and at nearly 5 Mc/s the extraordinary wave also vanished, it having then reached the same equivalent height of about 500 kilometres.

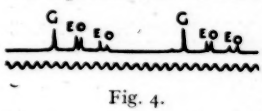


Fig. 4.

It was also found that at a constant frequency of 3.75 Mc/s the more penetrative ordinary wave failed to return in the evening about 2 hours before the extraordinary wave vanished, and at sunrise the latter appeared about half an hour before the former. These experiments were made on a 5 km base line in London.

If in the formula for κ the only variable is ω_0^2, which is proportional to N, κ is a linear function of N (*see* Fig. 3), for $\lambda = 80$m and $H = 0.43$. This shows the ordinary wave requires a higher electron density to produce a given reduction of κ.

Fig. 4 is reproduced from a now well-known oscillographic record obtained in these experiments at a frequency of 3.75 Mc/s. The first peak is the ground ray; this is followed about 2.5 milliseconds later by two echoes, the first being the extraordinary and the second the ordinary, as was determined by measurements made to decide their direction of rotation. The waves are then reflected from the earth and repeat the double journey, and another pair of echoes arrive, the interval between them being, of course, doubled. Owing to its greater penetration the ordinary wave not only arrives later but is slightly more damped than the extraordinary. The wavy line is a timing oscillation of accurately known frequency, viz. 1115 c/s.

Although we have made the simplifying assumption that the earth's magnetic field is in the direction of transmission, this detracts but little from the value of the results, since the effect of any transverse field is small. G. W. O. H.

Single-Section m-Derived Filters*

An Analysis of Low-Pass and High-Pass Types

By C. W. Miller, M.Sc.

(*Metropolitan Vickers Electrical Company*)

SUMMARY.—Analytic expressions are developed which determine the total insertion loss and phase shift of m-derived filter sections when terminated in a resistance equal to $\sqrt{L_k/C_k}$ and fed from a generator of the same impedance. These expressions are shown to be functions of m and K only, where K is the frequency ratio f/f_c (for the low-pass filter) and f_c/f (for the high-pass filter). It is shown that there are two possible types of circuit which become identical for $m = 1$ and a number of typical curves are given. Analytic expressions are also given for half section arrangements.

WHEN determining the characteristics of a filter network by the methods of generalised filter theory it is necessary to consider the total insertion loss (L) and phase shift (B) as consisting each of two parts. The first part consists of the loss and phase shift suffered in transmission through the network and values are calculated by assuming the filter to be terminated at each end by an ideal impedance known as the "image impedance," and then summing the loss and phase shift over all the individual sections. The second effect which must be considered is the loss and phase shift which is caued by the actual termination of the network being different from the ideal image impedance. In practice a network is often terminated with a pure resistance, and whilst over a large proportion of the pass-band this can be made to approximate closely to the image impedance, for other frequencies it may be widely different, and the mismatch causes loss and phase shift.

It has been shown by O. S. Meixell† that for the constant "k" low- and high-pass filters, the total insertion loss and phase shift may be obtained by a more direct method than that of the generalised

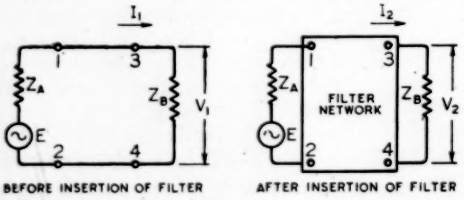


Fig. 1.

filter, and it is the purpose of the present paper to show that the same method can be extended to the m-derived filter, of which the constant "k" network is a limiting case. The method used deals with a filter terminated with a pure resistance R of the often used value $\sqrt{L_k/C_k}$ where L_k and C_k

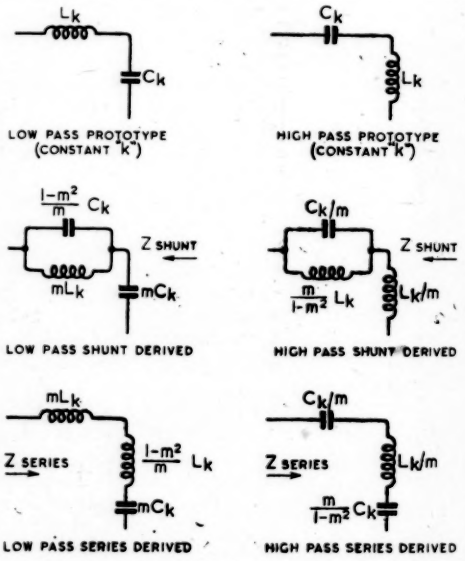


Fig. 2.—*Prototype (constant k) and* m*-derived half sections.*

$$L_k = \frac{R}{2\pi fc} \qquad C_k = \frac{1}{2\pi f_c R}$$

f_c = *cut off frequency* R = *terminating resistance*

$m = \sqrt{1 - (f_\infty/f_c)^2}$ *for high pass*

$m = \sqrt{1 - (f_c/f_\infty)^2}$ *for low pass*

when f_∞ = *frequency of infinite attenuation.*

are the values of the arms in the prototype constant "k" half section.

Before proceeding with the analysis, it is necessary to consider the meaning of "total insertion loss and phase shift." In Fig. 1 a network is

* MS. accepted by the Editor, July, 1943.

† O. S. Meixell, "An Analysis of Constant 'k' low- and high pass filters." *R.C.A. Review.* Vol. 5, No. 3, June, 1941.

inserted between a source of E.M.F. with impedance Z_A, and a load of impedance Z_B. Then, if the current in Z_B before the insertion of the network was I_1, and after the insertion is I_2, the vector ratio of the currents I_1 and I_2 given below determines, by definition, the insertion loss and phase shift. Thus

$$I_1/I_2 = \frac{|I_1|\angle\theta_1}{|I_2|\angle\theta_2} = |I_1/I_2|\angle\theta_1 - \theta_2 = |I_1/I_2|\angle B$$

and therefore

Total insertion loss in decibels $(db) = L = 20 \log_{10} I_1/I_2$ .. .. .. (1)

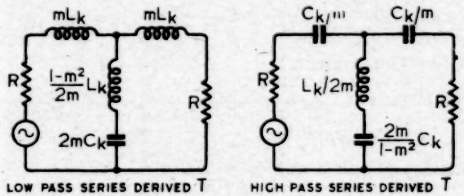
Total phase shift $= B =$ angle of I_1/I_2 .. (2)

From the above it is clear that the problem is to find the vector ratio I_1/I_2.

It is noted that before insertion

$$I_1 = \frac{E}{Z_A + Z_B} = \frac{E}{2R}$$

(When $Z_A = Z_B = R$ which will be true in the cases we shall consider).



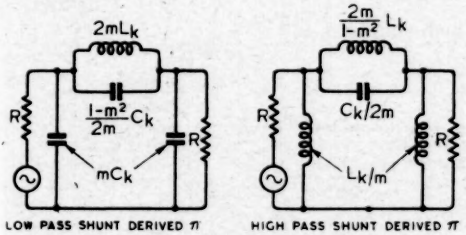


Fig. 3.—*Type A networks (complete section).*

$$I_1/I_2 = 1 - \frac{2m^2K^2}{1-(1-m^2)K^2} \pm jmK\left(\frac{2-K^2}{1-(1-m^2)K^2}\right) = X \pm jY$$

L = *total insertion loss* $= 20 \log_{10}|I_1/I_2|$
$= 20 \log_{10}\sqrt{X^2+Y^2} = 10 \log_{10}(X^2+Y^2)$ *decibels*

Total phase shift $B = \tan^{-1}(\pm Y/X)$

$K = f_c/f$ *for high pass and* $K = f/f_c$ *for low pass*

L_k *and* C_k *have values given in* Fig. 2

When choice of sign is given + *sign is used for low pass and* − *sign for high pass.*

After insertion $V_2 = I_2 Z_B = I_2 R$

$$\therefore \quad \frac{E}{V_2} = \frac{2RI_1}{RI_2} = 2I_1/I_2$$

and hence

$$I_1/I_2 = 1/2\ E/V_2 \quad .. \quad .. \quad (3)$$

We shall proceed to show how I_1/I_2 can be found in terms of $K = f/f_c$ for the m-derived single

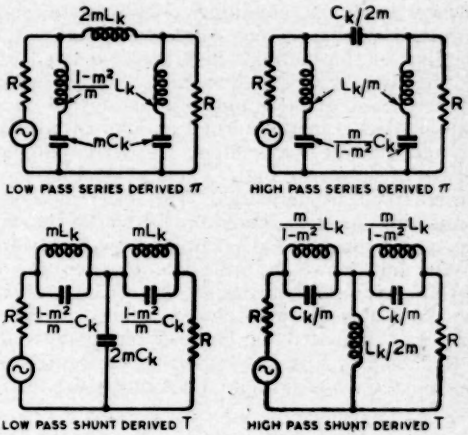


Fig. 4.—*Type B networks (complete section).*

$$I_1/I_2 = 1 - \frac{2m^2K^2}{1-(1-m^2)K^2} \pm jmK\left(1 + \frac{1-K^2}{\{1-(1-m^2)K^2\}^2}\right) = X \pm jY$$

L = *total insertion loss* $= 20 \log_{10}|I_1/I_2| = 20 \log_{10}\sqrt{X^2+Y^2}$
$= 10 \log_{10}(X^2+Y^2)$ *decibels*

Total phase shift $B = \tan^{-1}(\pm Y/X)$

$K = f_c/f$ *for high pass and* $K = f/f_c$ *for low pass*

L_k *and* C_k *have values given in* Fig. 2

When choice of sign is given + *sign is used for low pass and* − *sign for high pass.*

section filters, but must first digress to consider the design data available from general filter theory for the element values.

The normal T or π section of a constant "k" low- or high-pass filter can be considered as being built up from two identical half sections, and these half sections are shown as the prototypes in Fig. 2 and have the element values as shown. It is possible to derive from these two prototypes four modified half sections as shown. These modified half sections are such that if sections are built up by joining together two identical half sections in such a way as to expose the sides marked with the arrows in Fig. 2 for connection to further sections, then the image impedance is the same for all values of "m" and is equal to that of the constant "k" section built from the prototype half sections in the same way. If this procedure is reversed, i.e., if identical half sections are joined with the marked sides together, the image impedance of the complete section will not be equal to that of a similarly built constant "k"

section, and will be a function of " m " as well as of the prototype element values. In the design of composite wave filters the availability of sections of different " m," but the same image impedance is of fundamental importance; since, however, we are confining ourselves to single section networks, we may connect our half sections in either of the methods mentioned above. Connecting two identical half sections with the marked sides exposed to the input and the output of the section, that is in the normal manner of a section for a composite wave filter, we derive the four networks shown in Fig. 3, and we shall refer to these as type A networks. The other method of connection leads to four more networks shown in Fig. 4, and these we have denoted type B networks.

We shall now, in order to demonstrate the method, give the analysis of one of the networks, the particular example chosen being the type A network designated the low-pass shunt derived.

Referring to Fig. 5, we shall let unit current (in the axis of reals) flow in the terminating load R, i.e., $I_2 = 1 + 0j$.

Hence $V_2 = I_2R = R$

The designations of currents in other elements of the network are as shown in Fig. 5.

Now $I_{p2} = V_2/Z_{p2} = jRpmC_k$ where p has the usual significance of $2\pi f$ where f is the frequency.

And $I_s = I_2 + I_{p2} = 1 + jRpmC_k$.

The voltage between the points 1 and 2 $= E_{12} = V_2 + I_sZ_s$

$$= R + (1 + jRpmC_k)\left\{\frac{2jpmL_k \cdot 2m/jp(1-m^2)C_k}{2jpmL_k + 2m/jp(1-m^2)C_k}\right\}$$

$$= R + (1 + jRpmC_k)\left\{\frac{2jpmL_k}{1 - p^2(1-m^2)L_kC_k}\right\}$$

Whence

$$I_{p1} = \frac{E_{1\cdot2}}{Z_{p1}} = E_{1\cdot2} \cdot jpmC_k = RjpmC_k + (1 + jRpmC_k)\left\{\frac{-2p^2m^2L_kC_k}{1 - p^2(1-m^2)L_kC_k}\right\}$$

But

$$I_0 = I_s + I_{p1} = 1 + 2jRpmC_k + (1 + jRpmC_k)\left\{\frac{-2p^2m^2L_kC_k}{1 - p^2(1-m^2)L_kC_k}\right\}$$

Further

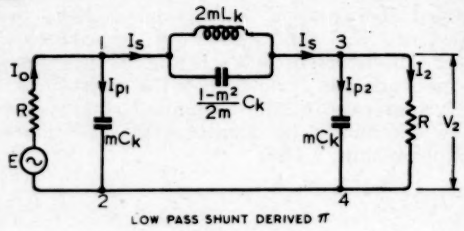
$$E = E_{1\cdot2} + I_0R$$

$$= R + (1 + jRpmC_k)\left\{\frac{2jpmL_k}{1 - p^2(1-m^2)L_kC_k}\right\} + R + 2jR^2pmC_k + (1 + jRpmC_k)\left\{\frac{-2p^2m^2L_kC_kR}{1 - p^2(1-m^2)L_kC_k}\right\}$$

$$= 2R + (1 + jRpmC_k)^2\left\{\frac{2jpmL_k}{1 - p^2(1-m^2)L_kC_k}\right\} + 2R^2jpmC_k$$

We have however previously shown that

$$I_1/I_2 = 1/2 \cdot E/V_2 = E/2R$$



LOW PASS SHUNT DERIVED π

Fig. 5.

$$\therefore \quad I_1/I_2 = 1 + (1 + jRpmC_k)^2\left\{\frac{jpm \cdot L_k/R}{1 - p^2(1-m^2)L_kC_k}\right\} + jpmC_k \cdot R$$

But from the circuit design it is known that

$$L_k = \frac{R}{2\pi f_c} = \frac{R}{p_c} \text{ and that } C_k = \frac{1}{2\pi f_cR} = \frac{1}{p_cR}$$

and therefore in the above expression we can substitute for

L_kC_k by $1/p_c^2$

for L_k/R by $1/p_c$

and for C_kR by $1/p_c$

and we thus obtain

$$I_1/I_2 = 1 + (1 + jmp/p_c)^2\left\{\frac{jmp/p_c}{1 - (1-m^2)p^2/p_c^2}\right\} + jmp/p_c$$

Writing now K for $p/p_c = f/f_c$

$$I_1/I_2 = 1 + (1 + jmK)^2\left\{\frac{jmK}{1 - (1-m^2)K^2}\right\} + jmK$$

Which simplifies to

$$I_1/I_2 = 1 - \frac{2m^2K^2}{1 - (1-m^2)K^2} + jmK\left\{\frac{2 - K^2}{1 - (1-m^2)K^2}\right\}$$

This last equation can be written in the form

$$I_1/I_2 = X + jY$$

where

$$X = 1 - \frac{2m^2K^2}{1 - (1-m^2)K^2}$$

$$Y = mK\left\{\frac{2 - K^2}{1 - (1-m^2)K^2}\right\}$$

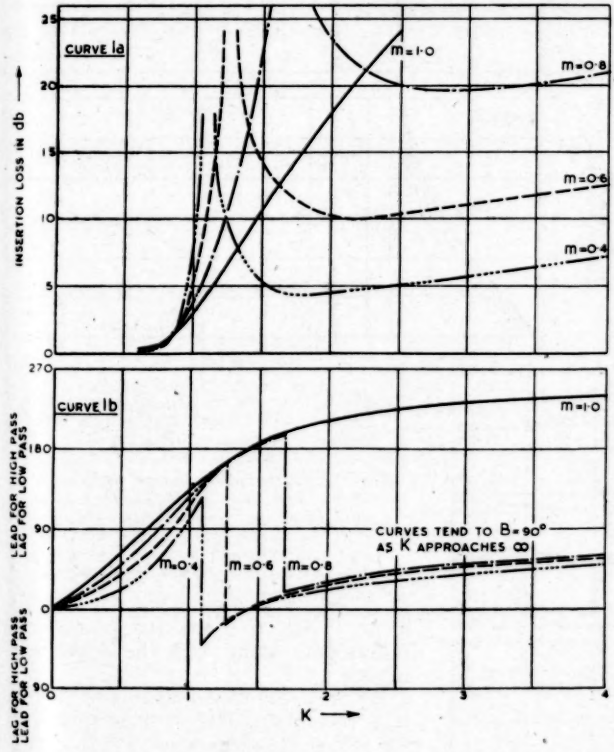
Whence

Total insertion loss

$$L = 20 \log_{10}|I_1/I_2| = 20 \log_{10}\sqrt{X^2 + Y^2}$$
$$= 10 \log_{10}(X^2 + Y^2)$$

and phase shift $B = \tan^{-1}Y/X$.

Similar treatment of the other low-pass type A network gives an identical result. When the same method is applied to the high-pass type A networks an expression for I_1/I_2 is obtained which is identical with the above except that the sign of the imaginary part is reversed and that



Curve 1. (a) *Insertion loss of type* A *network.* (b) *Phase shift for type* A *network.* B = *phase shift in degrees.*

K is now f_c/f. We have therefore as a general solution of the type A network that

$$I_1/I_2 = X \pm jY$$

where $$X = 1 - \frac{2m^2K^2}{1 - (1 - m^2)K^2}$$

and $$Y = mK\left\{\frac{2 - K^2}{1 - (1 - m^2)K^2}\right\}$$

$$L = 10 \log_{10}(X^2 + Y^2)$$

$$B = \tan^{-1}(\pm Y/X)$$

When a choice of sign is given + is to be used for low-pass networks and − is to be used for high-pass networks. also for low-pass arrangements $K = f/f_c$ whilst for the high-pass cases $K = f_c/f$.

Curves 1(a) and 1(b) show respectively the variation of L and B with K for typical values of m.

Indentical treatment of the type B networks yields for I_1/I_2 a similar but not quite identical expression and this is given along with the appropriate circuits in Fig. 4. Curves showing the variation of L and B with K are given in curves 2(a) and 2(b). For purposes of comparison curves 3(a) and 3(b) show the variation of L and B with K when the network is terminated at both ends by the ideal image impedance.

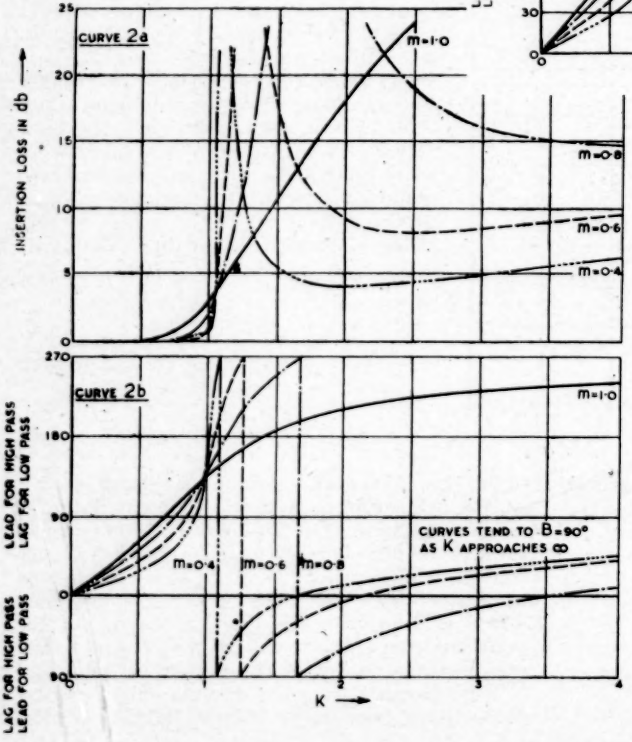
From inspection of curves 1, 2 and 3 various differences between the two types of network are noticed and also differences between the networks when terminated by a resistance R and when terminated by the ideal image impedance. As regards attenuation, it is noticed that the practical termination by R destroys the sharpness of the "cut-off" for both type A and type B networks. For type A networks, however, this "rounding-off" gets progressively worse for decreasing "m" whilst for type B the effect is a minimum when "m" has a value approximately equal to 0.6. It is because of this minimising of "rounding" that it has become standard practice to terminate a composite wave filter with a half section of $m = 0.6$ used in a manner analogous to the type B network. Another feature of interest is that whilst for a network terminated by its image impedance the attenuation after passing through infinity falls with increasing K to some constant value, when the network is terminated by R the attenuation first falls to a minimum which is somewhat less than the value for the perfectly matched case and then increases, finally approaching infinity as K approaches infinity.

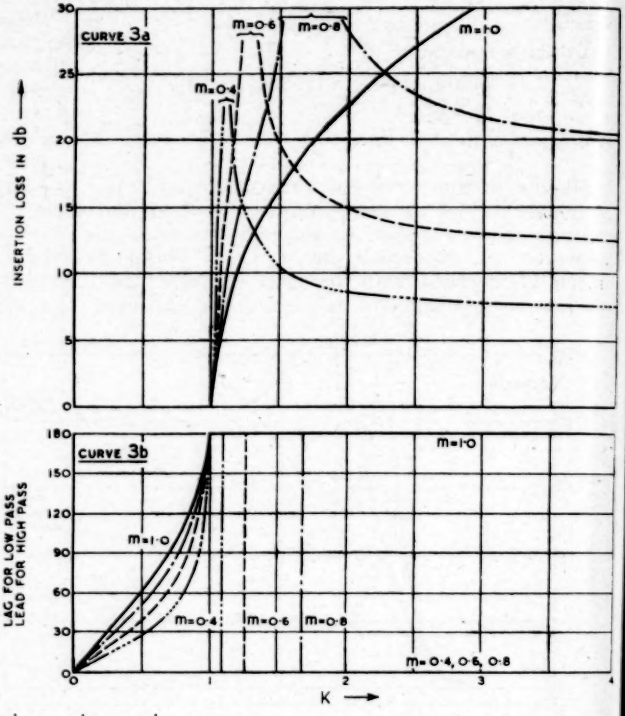
This property may in certain circumstances cause the R terminated network to have a more

desirable characteristic than the filter terminated with its image impedance. The differences in phase shift characteristics of various types of network are self-evident from the curves and require no comment.

It is of interest to note that when $m = 1.0$ the expressions for type A and type B networks become identical and, of course, agree with those obtained by Meixell for the constant "k" network.

The analytic treatment which has been used to determine the characteristics of single section networks can obviously apply to other arrangements. One particular case arises when a single half section of filter is connected to a generator and load both of impedance R. Again two types of connection are possible, as in the case of a complete section, but it is now found that method of connection has no effect upon the loss and phase shift characteristics and that in fact the same expressions are derived for all eight possible arrangements. Fig. 6 shows the possible arrangements along with the appropriate results.





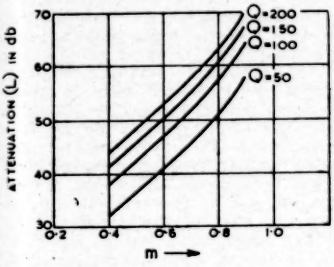
Curve 2 (left). (a) *Insertion loss of type* B *network.* (b) *Phase shift of type* B *network.* B = *phase shift in degrees.*

Curve 3. (a) *Insertion loss of single-section filter when both load and generator have ideal image impedance.* (b) *Phase shift for single-section filter when both load and generator have ideal image impedance.* B = *phase shift in degrees.*

By only slight modification of method it is possible to deal with arrangements for which the generator or load impedance is not equal to R, and the author has at present in preparation a paper in which is determined the behaviour of single m-derived sections terminated in R but fed from a generator which supplies either constant voltage or constant current. These are cases of great practical interest since they occur when a load, R, is fed through a filter section from either the anode of a pentode valve (constant current source) or

from a cathode follower output stage (constant voltage source).

In all the above analysis it has been assumed that the inductance coils are perfect, i.e. they have no series resistance. If, however, we assume that the Q of all coils are the same, then the series resistance of L_k is given by $p\,L_k/Q$ and since in



Curve 4. *Attenuation at $K = K_\infty$ for single section. Low or high pass filter terminated in image impedance.*

the analysis the impedance term jpL_k is used for perfect coils we must now use $(jpL_k + r)$.

But

$$jpL_k + r = jpL_k + \frac{pL_k}{Q} = jpL_k\left\{\frac{1 + jQ}{jQ}\right\}$$

Thus L_k can be replaced by $L_k\left\{\frac{1 + jQ}{jQ}\right\}$

If this is done then expressions for dissipative filters can be obtained. The effect of imperfect coils is to further increase the "rounding" near the cut-off frequency and this is most marked for low "m" and low "Q," also imperfection of the coils prevents the attenuation rising to infinity at $K = K_\infty$ and again the effect is more marked for low "m" and low Q.

It can reasonably be expected that for coils of Q greater than say 100 (such values can usually be obtained) the expressions for loss free coils will give results quite close to what would occur in practice, except in the immediate neighbourhood of the point at which they show the attenuation rising to infinity. At the point of infinite attenuation, however, since even with imperfect coils the transmission attenuation will be large, it will be safe to assume for practical purposes that the attenuation can be considered as being the same as that for a perfectly matched section. Curve 4 gives the variation of attenuation at $K = K_\infty$ with "m" for several values of Q.

Acknowledgment

The author wishes to thank Dr. A. P. M. Fleming, C.B.E., for permission to publish this paper.

At the suggestion of the Editor the Author has added, as an Appendix, definitions of some of the terms used in filter theory.

APPENDIX

Constant "k" filter—is a reactance network having inverse reactance arms, that is, the product of the impedances of the shunt and series arms is a constant which is independent of frequency and is in fact equal to

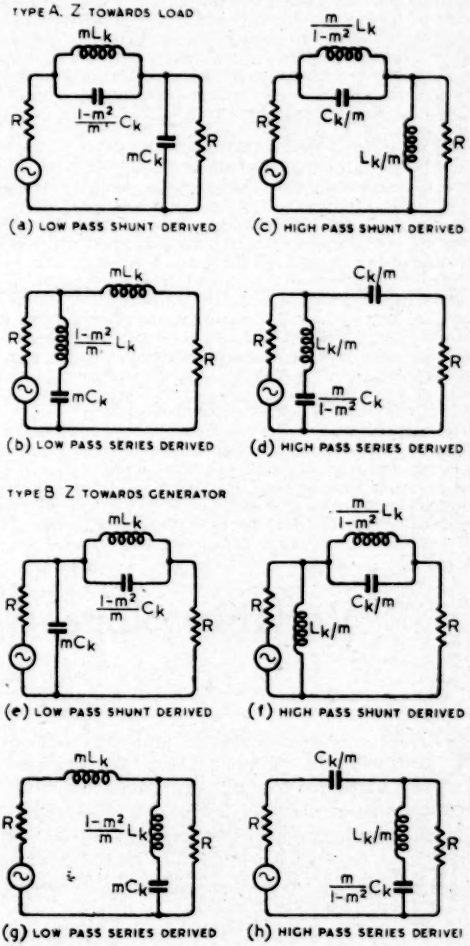


Fig. 6.—*Half-section filter.*

$$I_1/I_2 = 1 - \tfrac{1}{2}\frac{m^2K^2}{1 - (1 - m^2)K^2} \pm \tfrac{1}{2}jmK\left(1 + \frac{1}{1 - (1 - m^2)K^2}\right) = X \pm jY$$

L = total insertion loss (db) $= 20\log_{10}|I_1/I_2|$
$= 20\log_{10}\sqrt{X^2 + Y^2} = 10\log_{10}(X^2 + Y^2)$

Total phase shift $B = \tan^{-1}(\pm\, Y/X)$

$K = f_c/f$ for high pass and $K = f/f_c$ for low pass.

L_k and C_k have values given in Fig. 2

When choice of sign is given + sign is used for low pass and − sign for high pass.

k^2. A number of such arrangements are possible and, in particular, high-pass and low-pass filters can be designed to have this property, and the component values required are shown in Fig. 2. Such filters have, ideally, no transmission loss for frequencies greater than (in the case of high-pass) and lower than (in the case of low pass) a certain value, and this is known as the *critical frequency* or *cut-off frequency* and is denoted f_c. Beyond this critical value transmission loss occurs and gradually increases to infinity as the frequency approaches zero for high-pass filters or infinite frequency for loss-pass arrangements.

Image Impedance—can for the present purpose be defined as that impedance which when used as the termination of a network gives rise to no reflection, it can be shown that this impedance is in fact given by the geometric mean of the impedances obtained at the input of the network when the remote end is (*a*) short circuited and (*b*) open circuited. In general, a network will have a different image impedance at each end, although there are, of course, symmetrical arrangements having the same image impedance for both ends.

m-Derived Filters.—It is found that it is possible to modify the half sections of the constant "*k*" filter as shown in Fig. 2 in such a way that the transmission loss characteristic is altered and yet the image impedance at one side of the half section is unchanged. As a result of this property, it is possible to connect together correctly designed sections to form composite filters having transmission loss characteristics of any desired form.

The modification of the constant "*k*" half section can be done in two different ways. Firstly, the impedance of the series arm can be multiplied by a factor "*m*," and thus in order to maintain the image impedance (viewed from the free end of the series arm) at its original value modification of the shunt arm is necessary. The other possibility is to divide the impedance of the shunt arm by "*m*" and then maintain the original value of image impedance (now viewed from the shunt arm side of the half section) by modification of the series arm. These two new types of half section are known as "*series derived*" and "*shunt derived*" respectively, and although each type has one image impedance equal to the image impedance of the corresponding image impedance of the constant "*k*" half section, the other image impedances are neither equal to each other nor to the corresponding image impedance of the constant "*k*" half section. Due to this property, it is essential when building composite filters that care should be taken that half sections should only be connected together in a manner such that equal image impedances are presented to each other. The factor "*m*." in order that the networks should be real, must be positive and cannot exceed unity. It is found that the transmission loss characteristic is a function of "*m*" and is, provided the inductances and capacitances are pure, the same for both series and shunt derived arrangements of the same "*m*." The transmission loss characteristic is similar to that of the constant "*k*" section, except that the transmission loss in the "no-pass band" rises to infinity at a frequency depending on the value of "*m*." When *m* is equal to unity, this frequency becomes zero for high-pass filters and infinite for low-pass arrangements, and the arrangement becomes, of course, a constant "*k*" filter.

For further information on general filter theory, the reader should refer to "Transmission Networks and Wave Filters," by T. E. Shea (D. Van Nostrand, Inc.); "Transmission Circuits for Telephonic Communication," by K. S. Johnson (D. Van Nostrand Inc.); "Transmission Line Theory," by W. S. Franklin and F. E. Terman (Franklin & Charles).

Variable Slope with Constant Current*

By W. H. Stevens

(Research Dept., A. C. Cossor, Ltd.)

RADIO research workers, and, in particular, those circuit engineers who are engaged in the task of forcing the modern valve to perform the electronic acrobatics demanded by television and similar work, feel the need, sooner or later, of a valve having a modulating electrode which would operate only on the slope of the valve and not on its anode current.

Probably the most frequent requirement is the special case where it is desired to reduce the slope to zero, using the valve as an electrical "gate." Normally, by using standard biasing-off methods, this would mean that the anode current would also drop to zero, thus passing on to subsequent circuits a large, unwanted voltage surge. It is usually the case that the applied cut-off voltage is of transient nature and that the circuit time-constants have to be such that they pass this surge without substantially changing it, and objectionable effects arise because of it.

As an example, take the case of a composite television signal containing picture and synchronising information. At some point in the chain previous to modulating the radio frequency carrier, the picture signals have to be regularly interrupted, and masking and synchronising signals have to be inserted in their place. By cutting one of the video-frequency valves off with a pulse on one of its electrodes, a large voltage excursion occurs beyond the normal picture modulation limits, and this has to be brought back to a voltage corresponding to black level for the masking signal.

One method of doing this is to provide the amplifier valve with a partner whose anode current is cut off to a low value or even zero during picture transmission time, the anodes of these two valves being coupled together. When the amplifier valve is rendered inoperative by applying a negative switching voltage to one of its electrodes, so taking its anode current to zero, the partner valve

* MS. accepted by the Editor, September, 1943.

has a positive pulse applied to its grid, causing the anode current to rise to a certain value corresponding to black level for the masking signal. A further increase in the current through the partner valve at the appropriate time produces the synchronising signal.

The difficulty about this method is that it invariably gives rise to phasing or amplitude troubles, i.e. one current arrives at maximum before the other is at zero, or else the rates of rise and fall are not such that their sum is constant. This is due to the curvature of the valve characteristics and gives rise to a spurious positive or negative signal.

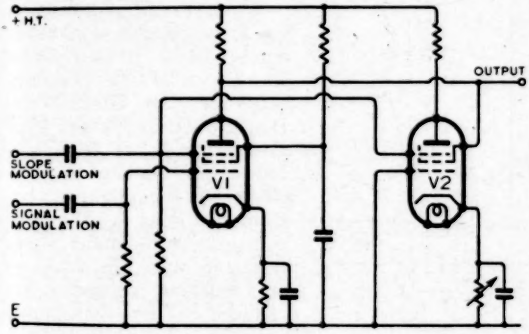


Fig. 1.

If some means could be found of so reducing the slope of the picture amplifier that the picture signal is suppressed, whilst not affecting the anode current, the problem would be simple. By arranging for D.C. restoration, the anode current in the quiescent state can be such that it corresponds to black level, thus giving the masking signal, and the injection of synchronising pulse is just a matter of adding a suitable wave-form at the correct instant.

A simple circuit which will give the desired result is shown in Fig. 1, V_1 being the valve whose slope is to be varied, and V_2 an auxiliary valve to maintain the current in the anode circuit. They are shown as of pentode type, but could equally well be hexode or other multi-electrode valves. The suppressors are coupled together, the screen of V_1 is maintained at a constant potential, and the anode of V_1 and the screen of V_2 are joined together to provide the output. The grid of V_2 is connected to earth.

The functioning of the circuit depends on the well known property exhibited by pentode or hexode valves that when the anode current is varied by negative voltage applied to the suppressor or outer grid the actual cathode current is not modulated; all that happens is that space current which was flowing to the anode is now turned back into the screen.

It can be seen, therefore, that if V_1 and V_2 are similar valves, and a negative potential is applied to the suppressor grids, the slope of V_1 will be reduced and the anode voltage on V_1 would want to rise by virtue of the reduction of the anode current. But the anode current of V_2 would be reduced similarly, the difference in the current passing to the screen of V_2. This screen current is drawn through the anode load of V_1, thus exactly replacing the current already lost, the nett result being that the voltage on the anode of V_1 remains unchanged.

Any modulation which is applied to the inner grid of V_1 is amplified and appears on its anode in the normal way, the gain obtained being dependent on the potential of the suppressor or outer grid.

By applying a fixed cathode bias to V_1, and making the cathode resistor V_2 variable over a greater range, it is possible to control the effect to suit different conditions. Thus by arranging the bias on V_2 to be less than that of V_1, it is possible to permit the slope-modulating signal to appear on the anode of V_1, but without the normal change of phase. On increasing the bias resistor of the auxiliary valve, this signal will be reduced, eventually disappearing altogether, and finally reappearing in the opposite phase as the cathode bias becomes greater than that of V_1.

Instead of a direct connection between the two suppressor grids, or between the anode of V_1 and the screen of V_2, couplings consisting of condensers and resistances may be used, provided that the necessary D.C. potentials are taken care of, and that the time-constants of the couplings are of suitable length. The time-constant of the input coupling to the suppressors is preferably made no longer than is necessary for the job in hand.

Because V_2 is a valve having the pentode type of characteristics, it is permissible, where great accuracy is not required, to omit the load resistance in its anode circuit. If the resistance is employed, it is of interest to note that a copy of the slope-modulating signal can be obtained in reversed phase on the anode, but which is, however, somewhat mixed up with a copy, in the same phase, of the modulating wave applied to the inner grid of V_1, owing to this signal being present on the screen of V_2.

Again, because V_2 is modulated on its suppressor, the cathode decoupling condenser across the cathode bias resistor can often be omitted as the slope-modulation signal does not affect the cathode current, although there is some variation due to the

signal impressed on its screen from the anode of V_1.

It is also possible to use a common cathode connection for the two valves which could, if required, be enclosed in one envelope, with the inter-connections made internally.

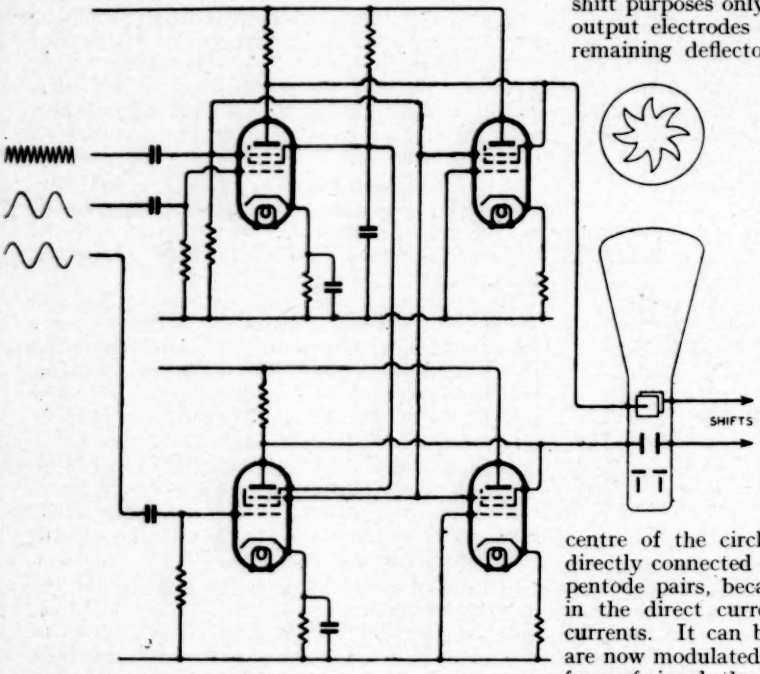


Fig. 2.

Under some conditions, with long wiring, it has been found that parasite oscillations have occurred when using high-performance pentodes for this valve combination, but it has been a simple matter to clear the trouble by introducing in the connection between the two suppressor or outer grids, a small resistance having a value of the order of 100 ohms.

An interesting application of this circuit is its employment for the production of radial deflections on a circular time-base in cathode-ray oscillography. In this case two similar pairs of pentodes connected as above described are used to produce the circular sweep and also to act as radial deflection amplifiers. Each pair is adjusted so that modulation applied to the suppressors causes no change in the anode voltage on the working pentode, V_1, when its inner grid is held at constant potential.

Sine wave signals 90 deg. out of phase with each other, are applied to the control grids of the working pentodes of the two pairs. The radial deflection signal is applied in the same phase to the suppressor grids of both pairs, which for this purpose may all be connected together. One deflector plate of the cathode-ray oscillograph for each direction of deflection is used for D.C. shift purposes only. Signals are applied from the output electrodes of one pair of pentodes to the remaining deflector plate for one direction, and from those of the other pair of pentodes to the remaining deflector plate for the other direction of deflection. This is shown in Fig. 2.

When no radial deflection signal is applied, a circular trace will be produced on the screen of the cathode-ray tube. By altering the D.C. potential of the suppressor grids of the pentodes the diameter of the circle will be changed, becoming smaller as the suppressors are made more negative, since the slopes of the working pentodes are reduced. There will, however, be no shift of the centre of the circle, even though the plates be directly connected to the output electrodes of the pentode pairs, because there has been no change in the direct current components of the anode currents. It can be seen that if the suppressors are now modulated with a saw-tooth or any other form of signal, the radius of the trace on the tube screen will be changed accordingly. The changes in the radial deflection will be solely those due to change of slope.

Another application of the circuit is its employment for abruptly quashing the gain of a radio frequency amplifier without introducing circuit ringing. This has hitherto involved the use of a push-pull amplifier, and the circuit described above offers an easier alternative method of accomplishing the same end. In this case, one stage of the amplifier is made the working valve of the pair, its inner grid having the radio frequency applied from the previous stage. The quashing signal is applied to the suppressor of sufficient amplitude to cut off the current in that stage completely. The substitution current from the other pentode in the pair is adjusted to be equal to the mean anode current of the working pentode when passing the radio-frequency signal. In this way, no shock signal is passed on to the following tuned circuits, and so circuit ringing is avoided.

Ceramic Insulating Materials*

Dielectric Properties at Centimetre Wavelengths

By W. Küsters

CONTENTS

Introduction.
I. Methods of Measurement.
(a) Theoretical basis of the measurement.
(b) Determination of loss angle.
(c) Measurement of the dielectric constant.
II. Measuring arrangements.
(a) Transmitter.
(b) Tuning device.
(c) Test line.
(d) Wavemeter.
III. Measurements.
IV. Evaluation of results.
Summary.
Bibliography.

Introduction

WITH the recent development of the short-wave field, the decimetre and centimetre waves become more and more important. It is above all the quasi-optical properties of these short electrical waves which so extends their field of application. The variety of application leads in turn to designs of apparatus, the construction of which calls for insulating materials which cannot always be kept within the desired narrow limits. This is true especially in the construction of energy conductors. In this application, as elsewhere in high frequency technique, ceramic materials are preferred on account of their low loss, as well as for the variety of shapes into which they can be easily formed, and for their high mechanical strength. With the increasing use of these materials it becomes important to measure their properties in the forms in which they occur in use, and at the high frequencies at which they are operated.

There are several methods of measurement known from high frequency technique, which can be used to determine dielectric properties at wave lengths from the long to the metre wave and even down to the decimetre wave region. However, the methods principally employed for metre and decimetre wave measurements are those involving the use of tuned lines (e.g. [1] to [6]). Methods involving a condenser in which the material under investigation is used as dielectric (e.g. [7]) cannot be used for centimetre waves, as it would not be possible to keep the dimensions of the apparatus small compared with the wavelength. Difficulties arise at these wavelengths when working with resonant lines also, in connection with the estimation of the losses in the line terminations, and with the small amount of transmitted energy available, as will be explained in detail later. In order to overcome these difficulties only optical methods have been used in the past to determine dielectric properties at centimetre wavelengths [8]. These have the advantage that the material under investigation need not be surrounded by metal, leading to the disappearance of the condition that the test samples must be small compared with the wavelength. Moreover an uncertainty is introduced with most materials when a metal coating is applied, as there should not be any air between the metal and the dielectric. This source of error is eliminated with ceramic materials if the required metal layer is burnt on, as is the case with the test samples employed in the present research. However, the outlay for the optical methods is appreciably greater, and the apparatus is of necessity far more complicated. The advantages of the optical methods cannot, however, be denied for wavelengths of a few centimetres and below 1 centimetre, especially for materials of high dielectric constant, as in these cases it is difficult to make the cross sectional dimensions of the line small enough.

I. Methods of Measurement

(a) *Theoretical basis of the measurement.* In the present research a resonance method employing a concentric line is used for measuring the loss angle and dielectric constant of solid insulating materials. The damping of the line is found in known manner [9] from the width of the resonance curve of the line when insulated with the material under investigation. From the damping factor β and the resonance wavelength λ, the loss factor $\tan \delta$ and the dielectric constant κ of the filling material can be calculated. The present method is distinguished by the fact that the errors can be perceived and eliminated experimentally. The experimental determination of the required corrections is of particularly great importance for the centimetre waves, as it is no longer possible to allow for the disturbing influences with suffi-

* Translation of the article "Über Messungen der dielektrischen Eigenschaften Keramischer Isolierstoffe bei Zentimeterwellen" which appeared in *Hochfrequenztech. u. Elektroakus.*, May, 1942, Vol. 59, pp. 129–137.

cient accuracy by means of the theory on account of the physical dimensions of the measuring apparatus being comparable with the wavelength. Although the concentric line has the disadvantage, in comparison with the parallel wire line, that it is difficult to couple inductively, nevertheless it has the advantage, which more than compensates for the disadvantages as regards this work, of being non-radiating, apart from the ends. The additional damping caused by radiation from the parallel wire line cannot be assessed accurately by means of the theory, and to determine it experimentally is a very complicated matter.

In the determination of β the largest error is due to the damping of the coupled-up measuring apparatus and to the radiation from the imperfectly terminated end of the line. The elimination of the effect of this error will be discussed later, when considering the calculations.

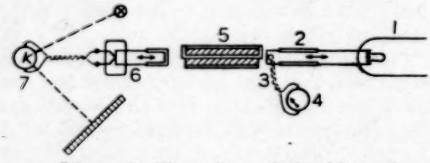


Fig. 1. *Schematic illustration of the Measuring arrangement.* 1. *Transmitter magnetron.* 2. *Tunable transmission line.* 3. *Thermo-couple.* 4. *Bench galvanometer.* 5. *Test line.* 6. *Vacuum thermo-couple with tunable line.* 7. *Mirror galvanometer.*

A second source of error is due to the low output of the transmitter for centimetre waves. Since, moreover, the apparatus in question is not very sensitive at these frequencies, it is not possible to couple the measuring leads to the transmitter sufficiently loosely completely to avoid feedback, and, in consequence, unintended variations of transmitter energy. Therefore, in order not to diminish the sensitivity of the high frequency measuring apparatus, the use of shunt circuits, which have been proposed in order to facilitate calculation of the effect of the measuring apparatus (compare [5, 10]) has been avoided. The transmitter output was continuously measured and maintained constant as described in the section " Measuring Arrangements ".

The resonance curve of the line is obtained by measuring the current at the receiving end of the line at varying frequency, the transmitter being inductively coupled to the sending end. A vacuum-type thermo-couple, also inductively coupled to the short-circuited end of the line, acts as current meter. The galvanometer deflection is thus proportional to the square of the thermo current. We first derive the relation between the width of the resonance curve thus obtained and the damping factor β of the line. It will be assumed that the end of the line is terminated by an ideal short-circuit. The known line theory equation

$$V_1 = V_2 \cosh \gamma l + I_2 . Z_0 . \sinh \gamma l \qquad .. \quad (1)$$

becomes, for $V_2 = 0$,

$$V_1 = I_2 Z_0 \sinh \gamma l$$

where V_1 = voltage at the beginning of the line.
V_2 = voltage at the end of the line.
I_2 = current at the end of the line.
Z_0 = characteristic impedance of the line.
$\gamma = \beta + j\alpha$ = propagation constant.
β = attenuation constant.
α = phase angle constant.
l = length of the line.

The characteristic impedance Z_0 is real, i.e. a pure resistance for very high frequencies. Its value is constant over the wave range in question. The voltage V_1 may also be taken as constant during the taking of the resonance curve [5, 10]. We may therefore write $V_1/Z_0 = B$,

$$\text{whence} \quad I_2 = B \frac{1}{\sinh \gamma l}$$

Since the instrument at the end of the line indicates the square of the magnitude of the current, $|I_2|^2$, the variation of this magnitude with wavelength must be calculated and discussed.

$$|I_2| = B \frac{1}{|\sinh \gamma l|}$$

On substituting $\gamma = \beta + j\alpha$ this becomes

$$|I_2| = \frac{1}{\sqrt{\sinh^2 \beta l + \sin^2 \alpha l}} . B \qquad .. \quad (2)$$

$|I_2|$ has a maximum for $\sin^2 \alpha l = 0$. Since $\alpha = 2\pi/\lambda$ this occurs when $l = k\lambda/2$, where $k = 1, 2, 3 \ldots$

How does $|I_2|^2$ behave in the neighbourhood of resonance, i.e. when the resonant wavelength λ_0 is varied by a very small amount $d\lambda$?

$$\text{We have} \quad \alpha l = \frac{2\pi}{\lambda_0 + d\lambda} . l$$

In this expression we may write $l = k . \lambda_0/2$

$$\text{and} \quad \frac{\lambda_0}{\lambda_0 + d\lambda} = 1 - \frac{d\lambda}{\lambda_0}$$

from which follows

$$\sin \alpha l = \sin \left(k\pi - \frac{k . \pi . d\lambda}{\lambda_0} \right)$$
$$= (-1)^{k+1} . \sin \left(\frac{k . \pi . d\lambda}{\lambda_0} \right)$$

Since in the neighbourhood of the maximum $\alpha l \ll 1$ the argument alone can be used in place of the sine, whence we obtain

$$\sin^2 \alpha l = \left(\frac{k \cdot \pi \cdot d\lambda}{\lambda_0}\right)^2$$

Since $\beta l \ll 1$, $\sin \beta l = \beta l$, and it follows from (2) that

$$|I_2|^2 = \frac{B^2}{(\beta l)^2 + \left(\frac{k \cdot \pi \cdot d\lambda}{\lambda_0}\right)^2}$$

When $l = k\lambda_0/2$ and $B^2/\pi^2 = A^2$ this becomes

$$|I_2|^2 = \frac{A^2}{\left(\frac{\beta \cdot k \cdot \lambda_0}{2\pi}\right)^2 + \left(\frac{k \cdot d\lambda}{\lambda_0}\right)^2} \quad .. \quad (3)$$

$$|I_2|^2 = \frac{A^2}{a^2 + b^2} \quad .. \quad .. \quad (4)$$

In the case of resonance $d\lambda = 0$, hence $b = 0$.

Variation of λ_0 by $d\lambda$ reduces $|I_2|^2_{max}$ to an m-th of its value, $|I_2|^2$ being given by

$$|I_2|^2 = \frac{|I_2|^2_{max}}{m} = \frac{A^2}{m \cdot a^2} = \frac{A^2}{a^2 + (m-1)a^2}$$

On comparing this with (4) we obtain

$$b^2 = (m-1)\, a^2$$

and from (3)

$$b^2 = \left(\frac{k \cdot d\lambda}{\lambda_0}\right)^2 = (m-1)\left(\frac{\beta \cdot k \cdot \lambda_0}{2\pi}\right)^2$$

From this the value of β is

$$\beta = \frac{2\pi \cdot d\lambda}{\lambda_0^2} - \frac{1}{\sqrt{m-1}} \quad .. \quad .. \quad (5)$$

At half the height of the resonance curve, i.e. at $|I_2|^2 = \frac{1}{2}\,|I_2|^2_{max}$, $m = 2$, and in this case

$$\beta_m = \frac{2\pi \cdot d\lambda}{\lambda_0^2} \quad .. \quad .. \quad (6)$$

Where $2d\lambda$ is the width at half the height and β_m is the attenuation constant found by means of a test measurement. For the small attenuation occurring with the measurements in question this formula fits quite well with the approximations made during the course of the calculation. With regard to the limits of accuracy, compare [9].

From (6) the attenuation constant of the line can be determined from the width of the resonnace curve. However, since the line is not terminated by an ideal short-circuit, the result will be too great numerically, firstly, because there is radiation from the end of the line (which, as can be seen from Fig. 5, is not symmetrically or completely short-circuited), and secondly because it is coupled to a strongly damped measuring circuit. The further analysis is therefore based on the assumption that the line is not short-circuited at its end, but feeds into a complex resistance Z_r. We may therefore write in equation (1) not $V_2 = 0$, but $V_2 = I_2 Z_r$. Equation (1) thereupon becomes

$$I_2 . Z_r = V_1 . \cosh \gamma l - I_1 . Z_0 \sinh \gamma l. \quad (7)$$

The general equation for the current in the end of the line is

$$-I_2 = \frac{V_1}{Z_0} . \sinh \gamma l - I_1 . \cosh \gamma l. \quad .. \quad (8)$$

From equations (7) and (8) I_2 may be found, and we have

$$I_2 = \frac{V_1}{Z_0} \cdot \frac{\cosh z}{\sinh (z + \gamma l)}$$

in which, according to Wallot [11] $\tanh z = Z_r/Z_0$. The rest of the calculation is similar to that leading to equation (6), and has been carried out by A. Dahme [5]. In a form of interest to us here, the result is

$$\beta = \frac{2\pi d\lambda}{\lambda_0^2} - \frac{r_1}{l} = \beta_m - \frac{r_1}{l} \quad .. \quad .. \quad (9)$$

in which r_1 is the real part of the magnitude z. It will be seen that as given by equation (6) the damping factor of the line is too great by the term r_1/l. It has already been stated that this error will be dealt with experimentally. This can be arranged quite satisfactorily by obtaining resonance curves with two test lines which are identical except for their lengths. Since, on account of the conductivity G, which really represents dielectric losses, the attenuation is dependent on frequency, the two test lines must have the same resonant wavelength. This will be the case if the difference between their geometric lengths amounts to $k\lambda_0/2$. It is necessary to employ the same wavelength for both test lines also on account of the rather narrowly limited oscillation range of the valves used for generating the centimetre waves in question. The correction r_1/l can then be eliminated in the following manner.

The measurement with a line of length l_1 gives

$$\beta_{m1} = \frac{2\pi \cdot d\lambda_1}{\lambda_0^2}$$

Correspondingly, for a similar line of length l_2

$$\beta_{m2} = \frac{2\pi \cdot d\lambda_2}{\lambda_0^2}$$

According to (9)

$$\beta = \beta_{m1} - r_1/l_1, \qquad \beta = \beta_{m2} - r_1/l_2$$

and hence

$$\beta = \frac{l_1\beta_{m1} - l_2\beta_{m2}}{l_1 - l_2} \quad .. \quad .. \quad (10)$$

This expression represents the actual damping factor β obtained from two measurements. It is conditional upon both lines having the same reson-

ant wavelength, and upon having the same measuring instrument coupled equally tightly to the end of the line for both measurements, as only in these circumstances will the impedance Z_r and hence the magnitude r_1 have the same value in the two cases. The impedance Z_r can be taken as constant over the frequency range in question.

The values for the wavelengths which have occurred in the calculations so far are valid generally. However, with the wavemeter used, the values measured are for the wavelength in air. The ratio between these values is expressed by means of the refractive index $n = \sqrt{\kappa}$. The wavelength in air is equal to $\lambda_L = n \cdot \lambda$, and $d\lambda_L = n \cdot d\lambda$. On making this substitution in the relevant equations, we derive from (6)

$$\beta_m = \frac{2 \cdot \pi \cdot d\lambda_L}{{\lambda_{L_0}}^2} \cdot n \qquad \ldots \quad (11)$$

On writing

$$\beta'_m = \frac{2 \cdot \pi \cdot d\lambda_L}{{\lambda_{L_0}}^2}$$

we derive from (10)

$$\beta = \frac{l_1 \beta'_{m1} - l_2 \beta'_{m2}}{l_1 - l_2} \cdot n \qquad \ldots \quad (12)$$

$$\beta' = \frac{l_1 \beta'_{m1} - l_2 \beta'_{m2}}{l_1 - l_2} \qquad \ldots \quad (13)$$

(b) *Determination of loss angle.* From the attenuation constant of the line we proceed to determine the loss angle of the intervening dielectric. For the test lines used, $R \ll \omega L$ and $G \ll \omega C$ as will be apparent from the numerical values given later, and β can therefore be calculated from the familiar approximate expression

$$\beta = \frac{R}{2}\sqrt{\frac{C}{L}} + \frac{G}{2}\sqrt{\frac{L}{C}} \qquad \ldots \quad (14)$$

where R, G, L, and C represent the specific values for the line, i.e. the values per unit length. From (14) we have

$$G = 2\beta\sqrt{\frac{C}{L}} - \frac{RC}{L} \qquad \ldots \quad (15)$$

The loss angle is defined by

$$\tan \delta = G/\omega C.$$

Making use of (15) we find

$$\tan \delta = \frac{2\beta}{\omega\sqrt{LC}} - \frac{R \cdot C}{\omega C L}; \quad \frac{1}{\sqrt{LC}} = C = \frac{\lambda_0 \omega}{2\pi}$$

$$\tan \delta = \frac{\lambda_0}{\pi} \cdot \beta - \frac{R}{\omega L}. \qquad \ldots \quad (16)$$

In order to enable the wavemeter readings to be used directly, equation (16) is transformed to correspond with equations (11) and (12), giving

$$\tan \delta = \frac{\lambda_{L0}}{\pi}\beta' - \frac{R}{\omega L} \qquad \ldots \quad (17)$$

In this form, the refractive index does not appear. Hence it is possible to find the loss angle without knowing the dielectric constant. The term $R/\omega L$ must be determined by calculation from the dimensions of the test line. The high frequency resistance R of the concentric line is found as follows [12]:—

For a cylindrical conductor,

$$\frac{R}{R_0} = x + \tfrac{1}{4} + \frac{3}{64x} \cdots$$

$$x = \frac{r_0}{2}\sqrt{\pi \cdot f \cdot g \cdot \mu}$$

$$R_0 = \frac{l}{{r_0}^2 \cdot \pi \cdot g}$$

where R is the high frequency resistance,

R_0 is the d.c. resistance,

r_0 is the radius in centimetres,

f is the frequency,

g is the specific conductivity of the conductor material, and

μ is the permeability of the conductor material.

For the frequencies in question we may put $R/R_0 = x$.

We then obtain the following values for concentric conductors (e.g. according to [15]) in ohms per cm.:—

$$\left.\begin{array}{ll} \text{for silver} & R_s = 8.025\left(\frac{1}{d_1} + \frac{1}{d_2}\right)\sqrt{f} \cdot 10^{-8} \\ \text{for copper} & R_c = 8.38\left(\frac{1}{d_1} + \frac{1}{d_2}\right)\sqrt{f} \cdot 10^{-8} \\ \text{for brass} & R_b = 16.8\left(\frac{1}{d_1} + \frac{1}{d_2}\right)\sqrt{f} \cdot 10^{-8} \end{array}\right\} \quad (18)$$

where d_1 is the inner diameter of the outer and d_2 the outer diameter of the inner conductor. The self-inductance of the concentric conductor is

$$L = 4.61 \log_{10}\frac{d_1}{d_2} \cdot 10^{-9}\ H/cm. \qquad \ldots \quad (19)$$

With the measuring lines used, the internal inductance L_i of the line, which may be found from the relation

$$\frac{\omega L_i}{R_0} = x - \frac{3}{64x} + \frac{3}{128x^2} \cdots$$

is, as can be shown by a numerical calculation, of the order of 10^{-3} times the external inductance L, and can therefore be neglected.

(c) *Determination of the dielectric constant.* The precise determination of the dielectric constant

κ or refractive index n of an insulating material necessitates a number of measurements with test lines of different lengths. It is then possible to eliminate one unknown, representing the difference between the electric and the geometric length of a line. The reason for this difference is the presence of the termination at the end of the line, which acts as an extension of the line. The amount of the error due to this cause will in the following be designated b (" bridge shortening "). Thus

$$l = k\frac{\lambda_0}{2} - b\,.$$

With $\lambda_0 = \lambda_{L0}/n$

we have for two different line lengths

$$k_1\lambda_{L1} = 2nl_1 + 2nb$$
$$k_2\lambda_{L2} = 2nl_2 + 2nb$$

Hence
$$n = \frac{k_1\lambda_{L1} - k_2\lambda_{L2}}{2(l_1 - l_2)} \quad .. \quad .. \quad (20)$$

and
$$b = \frac{l_1k_2\lambda_{L2} - l_2k_1\lambda_{L1}}{k_1\lambda_{L2} - k_2\lambda_{L2}} \quad .. \quad .. \quad (21)$$

The magnitude k can be estimated with certainty for short lines ($k = 2$ to 3) if n is known approximately. Otherwise k must be determined by finding two resonant wavelengths of a test line. With a long line ($k \simeq 20$) two consecutive resonant wavelengths are found, for which k differs by unity. Then

$$k_1\lambda_{L_I} = 2nl + 2nb$$
$$(k_1 + 1)\lambda_{L_{II}} = 2nl + 2nb$$

so that
$$k_1 = \frac{\lambda_{L_{II}}}{\lambda_{L_I} - \lambda_{L_{II}}} \quad .. \quad .. \quad (22)$$

II. Measuring Arrangements

In setting up the measuring arrangements, the requirement indicated by experience must be carefully borne in mind, viz. that the frequency generated must be very constant and must be susceptible of fine variation. The high frequency energy also must be controllable within narrow limits.

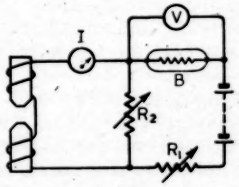


Fig. 2. *Arrangement of the magnetron field circuit.*

(a) *Transmitter.* Various magnetrons are available for use as transmitter. There are double-slit magnetrons, in which the high frequency energy is taken off capacitively from the two anode halves. The length of the oscillating loop connecting the anode segments is so chosen that the valve output is a maximum at a wavelength of about 9 cm. The valve is mounted between the pole shoes of an electro-magnet. The exciter winding of the magnet is fed from an accumulator of ample capacity. Since the magnet current has to be very constant, it is stabilised by an iron-hydrogen barretter. Even though the voltage of a large accumulator may be sufficiently constant, nevertheless the temperature coefficient of the resistance of the exciter winding leads to an impermissible fluctuation of the current from its set value as a result of the continuous variation of the current strength while the resonance curve is being taken. The magnet current circuit is therefore arranged as shown in Fig. 2. The characteristic of the barretter B had to be taken, in order to determine the best control range. The voltmeter V was read to ensure that the lamp was actually operating in this most favourable range. The magnet current I was regulated by means of R_2 while at the same time the voltmeter was brought to the desired reading by means of R_1. In order to obtain a sufficiently fine control, the resistance R_2 must be composed of a number of resistances in series or parallel. The magnetron heating current was also taken from a large accumulator. In this case stabilisation was not called for.

The anode current was supplied by a series arrangement of dry batteries, in series also with a voltage source capable of fine control. The latter consisted of the parallel connection of a number of accumulators with a potentiometer for tapping off the fractional voltage. The stability of the anode voltage was checked by measurement of anode current, and was maintained by manual control. Instabilities of the transmitter are immediately recognised by the abnormal asymmetry of the recorded resonance curves. To protect the magnetron against back-firing, a fine high voltage 10 mA fuse was included in the anode current circuit. The combination of a protecting resistance in series with the fuse was later abandoned owing to the loss of anode voltage involved. The fuse proved in operation to be a sufficient protection.

(b) *Tuning Device.* The set-up is described with reference to Fig. 3. The transmission line S is the continuation of the line sealed into the magnetron R, and takes the high frequency capacitively from the anode segments. The line consists partly of narrow tubes, and partly of wires running through them. The length of the line can thus be varied and tuned to the frequency generated by the transmitter valve. It is terminated at its end by the low resistance heater of a thermo-couple Th, whose high frequency current is maintained constant while the resonance curve is taken. The

thermo-couple is located within a small cavity hollowed out of two small sheets of vulcanite laid one on top of the other.

It is necessary that the transmitter line shall be tuned to the transmitter during the measurement. At the same time the coupling between the transmitter and the test line P on the one hand, and

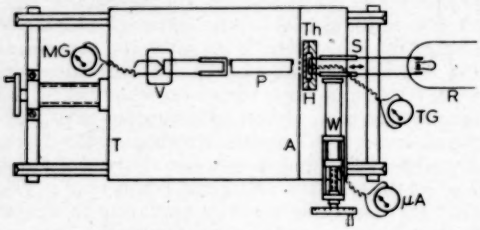


Fig. 3. *Plan of apparatus.* (*Th in section*).

between the test line and the measuring apparatus on the other hand, must be kept constant. On account of the mass of the heavy electromagnet, it is not easy to arrange for the transmitter to have its position adjusted, and the construction was therefore as follows:—A wooden platform T is arranged to slide along two wooden rails of triangular profile, the platform being driven by a winding handle at its left-hand end. The position of the platform can be read on a vernier scale. The rails are screwed to the laboratory bench and well waxed with beeswax. Across the platform, about 5 cm. from the right-hand end, is an aluminium panel A. In the middle of this panel are secured the two vulcanite sheets between which is hollowed the cavity containing the thermo-couple Th. The screening panel has a small opening at this point (shown dotted in Fig. 3). The test line is set up to the left of this panel and is coupled through the opening to the heater of the

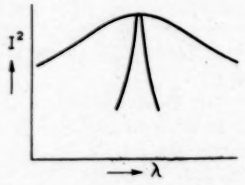


Fig. 4. Upper: *Resonance curve of the parallel wire line connected to the vacuum junction V.*
Lower: *Resonance curve of a test line.*

thermo-couple, and thus to the transmitter. On shifting the platform by means of the winding handle the length of the transmission line S is varied, and can thus be tuned to the transmitter. Correct tuning is achieved when the galvanometer TG indicates maximum thermo voltage. The above requirement is then fulfilled, viz. that the coupling of the test line and of the meter V with one another and with the transmitter remain constant.

In order to measure the current at the end of the short-circuited test line, a highly sensitive vacuum thermo-couple V is coupled to it. This forms the termination of a tunable parallel wire line. On account of the relatively high terminating resistance through the heater of the vacuum thermo-couple, the resonance curve of this line is very broad (Fig. 4). It is only necessary to tune this line once, approximately to the resonant wavelength of the test line. The high frequency currents flowing in the heater are very small, so that the thermo voltage can conveniently be measured by means of a mirror galvanometer MG. To improve the stability, the vacuum bulb was surrounded with cotton wool and a Pertinax cylinder. This apparatus is mounted on the wooden platform, close to the test line.

(c) *Test line.* As already mentioned, a concentric line was used for the test line. As a check, several measurements were made first with air lines. These were obtained as follows. A wire of 1 mm. diameter was arranged quite unsupported within a brass tube of 4 mm. internal diameter. The ends of the wire were bent at right angles, fitted into the tube wall, and soldered there (Fig. 5). This manner of terminating the line was chosen after a number of trials as being the most practical. Above all, lines of this type can be coupled to others as satisfactorily as parallel wire lines. The increased damping of the line due to the imperfect termination has no significance in the method of measurement employed, as it simply effects an increase of the impedance Z_r. In order to determine the dielectric properties of an insulating material, the line is filled with the material under investigation. For the ceramic materials investigated, small tubes were made for this purpose, having an external diameter of about 4 mm. and a bore of about 1 mm. These test pieces were coated internally and externally with a layer of silver burnt on and then electrolytically built up. At each end was a strip of silver about 1 mm. wide connecting the inner and outer conductors. The metal body so formed thus had the same configuration as the air line illustrated in Fig. 5. With test pieces prepared in this way it is ensured that there is no air layer between the dielectric and the conductor, so that sources of error associated with the presence of a double layer condenser are eliminated. Since the penetration is very slight at these high frequencies (5 μ at a frequency of 2×10^9

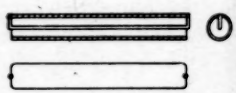


Fig. 5. *Air dielectric line.*

c.p.s.), the metal layer needs to be only a few hundredths of a millimetre. In choosing the diameter of the test lines it had to be borne in mind that the measurements were dealing with an insulating material having a very high dielectric constant. For Condensa *C*, for example, $\kappa = 80$. If a test line is made with this material, it is extremely important to remember that the wavelength along this line is only about a ninth of the wavelength in air. Hence for centimetre waves the danger arises that the transverse dimensions of the line are no longer sufficiently small in comparison with the wavlength. Therefore in order to be able to investigate materials of this class right down to wavelengths below 10 cm., the diameter of the test line is not allowed to exceed say 4 mm. It was confirmed by experiment that a line of this type can be coupled, both to the transmitter and to the vacuum thermo-couple, so tightly that the sensitivity of the mirror galvanometer is far from being fully used. For the following reasons, however, the thickness of the line cannot be decreased indefinitely. When the value of *G* is calculated from the formula (14), the accuracy increases if the second term is as large and the first as small as possible. It is therefore desirable to make the ratio L/C, and hence the characteristic resistance, as large as possible, i.e. to make the line as wide as possible, with a thin internal conductor.

(d) *Wavemeter.*—The limits of accuracy of the method of measurement described are set by the accuracy with which the width of the resonance curve of a test line is determined. Thus especial care must be taken with the construction of the wavemeter. A tunable line is employed as wavemeter. Since the resonance indication of this line is the more exact the sharper the resonance curve,

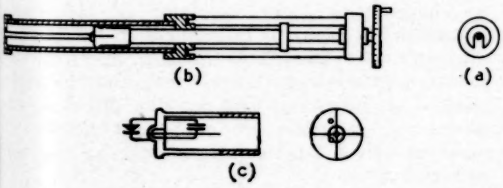


Fig. 6. *Wavemeter.*

a concentric line is the obvious thing to use, as there is then no damping due to radiation (Fig. 6). The variation of length required for tuning is performed by sliding a piston by rotation of a micrometer screw. The piston is secured to the screw in such a way as to avoid rotation of the former with the latter. Since it is required to measure wavelength variations of 2μ ($1\mu = 1/1000$ mm.), as will be explained in greater detail under the discussion of errors, the screw drive is required to satisfy the closest mechanical specifications. The greatest difficulties are experienced in constructing the piston so that it always makes contact with the inner and outer conductors at the same points or lines, regardless of its position along the tube. As long as this requirement is not satisfied, the resulting fluctuations of the resonance-indicating instrument make it impossible to determine the resonance with the necessary accuracy. This requirement also precludes the use of pistons provided with rings to improve the contact with the outer tube [14] because of the indefiniteness of the contact points both between piston and ring and between ring and tube wall, as proved experimentally. As a result of a long series of trials, the piston shown in Fig. 6c was developed. This is provided with a flange for contacting the outer tube and with four small springy members for contacting the inner tube. The whole piston is split quadrantally so that it presses springily against the inside wall of the larger tube. This results from the spreading effect due to the pressure of the inner tube on the spring members. To ensure good contact it is also necessary to use, at least for the outer conductor, precision tubing which is well ground inside. The screw has a pitch of 0.5 mm. The scale, in hundredths of a mm., is marked on the plate of the driving handle at a diameter sufficiently large so that piston displacements of 1μ can be read satisfactorily. The coupling of the wavemeter with the transmission line is arranged in the same way as for the test line. The inner conductor is, as in the former case, connected with the outer conductor only by means of a strap (Fig. 6a). The arrangement of the wavemeter in the complete set-up is shown in Fig. 3.

Fig. 7. *Detector.*

For the wavemeter it was first attempted to use a parallel wire line, and the widest variety of possibilities of indicating resonance was investigated. In this connection the following requirements have to be satisfied: The indicating instrument should (1) as far as possible form one unit with the wavemeter, (2) require no additional tuning, and (3) not damp the wavemeter, so that the resonance curve remains sharp. Experiments showed that the most practical way was to measure the current in the movable short-circuiting bridge. As the sharpness of resonance of the parallel wire line did not yield the required degree of accuracy, indicated above, a concentric line was next tried as wavemeter. In this case also the current in the movable short-circuiting bridge, i.e. the piston,

was to be measured. This problem was solved by building into the piston a small untuned circuit including a detector and a condenser as shown in Fig. 6. The short wire leads through the end of the piston are so arranged that one wire runs as closely as possible along the outer conductor and the other along the inner. When the high frequency current in the piston is maximum, i.e. at resonance, the current in the concentric conductors near the piston is also maximum and induces a voltage in the small measuring circuit. The rectified current flowing in the detector is fed to a micro-ammeter. Difficulties due to the high frequency current in the galvanometer leads may be avoided without using chokes if two thin, twinned, shellac-insulated wires are used for the leads. Alternatively high frequency multiply-stranded wire is suitable.

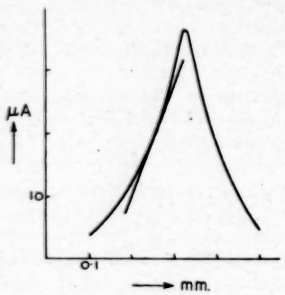


Fig. 8. *Resonance curve of the wavemeter.*

A silicon detector was used, with a tungsten point. The construction can be seen from Fig. 7, which shows a section. The housing consists of two vulcanite shells. The contact screws are slotted in such a way that the detector can be clamped between two slightly springy wires.

Fig. 8 shows the resonance curve of the wavemeter at the second current antinode. It is possible to establish the position of the resonance peak with an accuracy of at least 10μ. In order to make full use of the scale accuracy of the micrometer drive, which is readable to 1μ, as stated above, the procedure should be to take two settings, at the steepest parts of the curve on both sides of the peak, at which the detected currents are equal. The resonance peak then lies exactly halfway between these two points. With a little practice, variations of wavelength of 1 to 2μ may be determined in this way. As shown in Fig. 8, the slope of the sides of the curve is $5\mu/\mu$A. It will certainly be possible to find two rectified current readings equal with an accuracy of 0.02μA, thus making full use of the mechanical accuracy of the wavemeter. In order to determine a wavelength absolutely it is only necessary to find the distance between two resonance peaks corresponding to two antinodes of the wavemeter.

III. Measurements

The procedure for making the measurements is first to find the resonant wavelength of the test line. The resonant wavelengths for values of k differing by unity lie sufficiently close together to be located with certainty by varying the wavelength generated by a magnetron only for relatively long lines ($k = 15$ to 20) having an insulating material of high dielectric constant. If the dielectric constant of a material is known approximately, then it is better to choose short lengths for the test line ($k = 2$ to 5), since k can then be estimated. It is then unnecessary to determine the length of the line by experiment so that two resonances can be excited by the transmitter (compare end of Section I). If no resonance can be found, the test line must be shortened a few millimetres at a time until the vacuum thermo-couple does indicate resonance.

The variation of the transmitter wavelength is performed by continuously controlling the magnet current while maintaining the tuning of the transmission line by sliding the wooden platform. The oscillation of the transmitter is indicated by the bench galvanometer *TG* (Fig. 3). Since the resonance curve of a low-loss test line is very narrow, and the thermo-couple, owing to its low high frequency current, produces appreciable time lag in the galvanometer indication, the variation of the wavelength must be performed very slowly while the resonance is being sought in the first place. It may be noted in connection with the instrument *TG* that this helps to ensure that the oscillations do not break off due to too great detuning between transmitter and transmission line. The first search for resonance is made with the tightest coupling between test line and transmitter and the instrument *V*. At the resonant wavelength the light indicator of the mirror galvanometer is set to full deflection by loosening the couplings. The spaces thus introduced between the transmitter line, the test line, and the instrument *V* are measured with distance pieces, as they have to be set at the same values for the measurement of tan δ for the second test on the same material.

In order to determine the width of the resonance curve, the whole curve is traced, as this gives the greatest accuracy. As a measure of the wavelength the positions of all the current antinodes observable with the wavemeter are noted. Theoretically it should be possible to find not only the resonance wavelength but also one other shorter or longer wavelength at which the square of the current at the end of the test line has fallen to half its peak value. However, during the experiments it appeared that these two values did not lie

symmetrically with respect to the resonant wavelength. The discrepancy arises owing to the difficulty of determining the resonant wavelength without disturbance, on account of the time lag of the thermo-couple. If a detector measuring circuit were employed at the end of the line, this difficulty would disappear. In practice, however, it is not possible to obtain the detector characteristic satisfactorily at the frequencies in question, whereas the square law characteristic of the thermoelement is well known and a calibration in I^2 is the most useful for the measurements.

When taking the resonance curve the wavelength of the transmitter is varied by controlling magnet current. In doing this, care must be taken that the deflection of the instrument *TG* does not vary, so that the voltage at the beginning of the test line remains constant. There are several possible methods of controlling the high frequency current at the end of the transmission line. The first is to vary the anode voltage by means of the fine control described in Section II. Alternatively the high frequency output can conveniently be varied by slightly detuning the transmission line with respect to the transmitter. The alteration of wavelength brought about in this way is usually so small as to constitute only a very slight shift from the wavelength fixed by the chosen measuring point. If the detuning is too great, the oscillations break off.

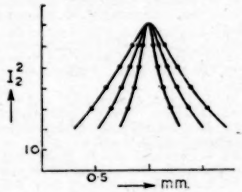


Fig. 9. *Resonance maxima of the wavemeter for a calit sample.*

In order to determine the dielectric constant, it is advisable to plot the whole resonance curve, even though it is only required to know the resonant wavelength, as this greatly increases the accuracy.

IV. Evaluation of Results

From equation (13) the result is obtained from the difference of two measured magnitudes. Hence it is possible that small errors in the measurements may falsify the results appreciably. By proceeding appropriately with the evaluation, errors of measurement can be clearly recognised, and something more will now be said on this point. In the preceding Section it was mentioned that when making the measurement for each point of the resonance curve, the positions of all maxima observable on the wavemeter should be noted. The wavemeter used was somewhat longer than 1.5λ, so that three resonance points could be observed. Thus, with the mirror galvanometer deflection as ordinate, three resonance curves could be traced for one test line. The following conditions must hold: (1) All three curves must be similar; (2) The differences between the positions of the resonance peaks must be equal, viz. $\lambda_L/2$; and (3) The widths of the resonance curves at half the height must stand in the ratio 1 : 2 : 3. Though this procedure may seem complicated, nevertheless it is less trouble than maintaining a continuous check on the absolute equality of distance between the resonance points observed on the wavemeter. There are, moreover, three resonance curves available of equal authenticity, by comparison of which errors arising in the course of measurement can be recognised without necessitating a repeat measurement on one point or the other (compare Fig. 9).

The value found for the resonant wavelength (λ_{L0}) and the width of the resonance curve ($2d\lambda_L$) yield the magnitude β' according to equation (13), which, for the purpose of this evaluation, may usefully be written in the form

$$\beta' = \frac{2\pi}{l_1 - l_2}(l_1 d\lambda_1 - l_2 d\lambda_2)\frac{1}{\lambda_{L0}^2}$$

Tan δ can also be found (17) from the calculation of $R/\omega L$, as explained in detail in Section 1. The method of determining κ from the resonant wavelength is also sufficiently described in that Section.

Measurements were first made with a concentric line in air. The damping of such a line may be calculated immediately from the expression

$$\beta = R/2Z = \beta'$$

The agreement with the measurement was very good, as will be seen from the Table below. The

Material			$\beta' \cdot 10^{-4}$ cm.		tan δ	κ	Error $\pm$ % for tan δ	Kebbel's Measurements at 6.25 cm.
Conductor		Dielectric	Calculated	Measured				
Brass	Air		7·25	7·3	—	—	—	—
Silver	Calit		—	—	8×10^{-4}	6.49	12	7×10^{-4}
Silver	Tempa		—	—	15×10^{-4}	14.1	7	—
Silver	Condensa		—	—	14×10^{-4}	78.8	6	15×10^{-4}

Results of measurements at wavelengths between 8.5 and 9.5 cm.

limits of error are given on the assumption that the width of the resonance curve is measured with an inaccuracy of 1 to 2μ. The table shows the largest possible error, since it is assumed that λ_{L1} is measured too large and λ_{L2} too small, or *vice versa*.

Taking into consideration the limits of error and also the fundamental difference between the method used here and that of Kebbel, the agreement of the measured results for Calit and Condensa is very good. For Tempa the result gave a loss angle at the wavelengths used which was surprisingly large in comparison with previously known values (tan $\delta = 1$ to 2×10^{-4}) [16, 17].

No limit of error was given for the value of κ as the possible inaccuracy in the calculation of n appears only in the third decimal place. The limits of error given have no universal validity for the method employed. Since β' and tan δ are obtained as the difference of two measured values, the result becomes the more accurate the greater the difference in comparison with the measured values. For this reason the ratio of the lengths of two tests of any one material should not be chosen too small (k about 2 to 5), as the accuracy of β' is thus increased. The accuracy of tan δ increases with the magnitude of the loss angle and decreases with increasing $R/\omega L$ (compare (17)).

Summary

An account is given of a method of measuring dielectric losses of solid insulating materials at centimetre waves. In order to achieve high accuracy there is developed a resonance method of measuring the damping of concentric lines. The method is characterised by the advantage that all the errors usually arising in measurements of this kind, as a result of effects due to the measuring apparatus and radiation from the ends of the line, are completely eliminated experimentally. The procedure is therefore particularly suitable for measurements in the centimetre wave range, where up to the present only optical methods have been used for measuring dielectric losses. The efficacy of the method is demonstrated by a series of measurements on ceramic insulating materials. The measuring arrangement employed, as well as the measuring procedure and the evaluation of the results, are described in detail. An especially accurate wavemeter was developed in connection with the experiments carried out.

The work here described was carried out at Karlsruhe Polytechnic.

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Book Reviews

Radio Receiver Design

By K. R. Sturley, Ph.D., B.Sc., A.M.I.E.E. Pp. 435 + xii. Chapman & Hall, Ltd., 11, Henrietta Street, London, W.C.2. Price 28s.

This book covers only the radio-frequency side of receiver design, starting with the aerial and ending with the detector. In his preface, the author states that this has been necessitated by war conditions and that the remaining material—A.F. amplification, television, frequency modulation, etc.—will be included in a subsequent volume.

Because this is only one-half of the complete book, it has a curious lack of completeness and it reads more like a collection of articles than a book. The second half will be awaited with great interest, for it will doubtless contain those chapters necessary to pull it together and make it a complete whole.

This volume starts with an introductory chapter on general principles in which the various forms of modulation are briefly explained. There are only four pages on frequency modulation and the treatment seems somewhat inadequate. This may be doing the author an injustice, however, for the shortcomings here may be made up in Part II, in which frequency-modulation receivers are to be treated. Incidentally, this well illustrates the difficulty of fairly reviewing one-half only of a book!

The second chapter deals with valves. After a brief description of the principles involved, the author goes on to treat the use of valve characteristics and discusses methods of drawing load diagrams on the valve curves. Although the necessary information is all there, this part could have been treated at greater length with a gain in clarity. One imagines that the author felt it to be so well known that it needed inclusion only for the sake of completeness.

Valve equivalent circuits are very thoroughly treated, and in such a way as to include the effects of the valve inter-electrode capacitances on the input admittance. The treatment, in fact, forms a basis for other feed-back effects, and constant reference is made to this material in later parts of the book. The chapter concludes with a brief discussion of electron transit time.

The third chapter—on aerials and aerial coupling circuits—is a long one, occupying no fewer than 63 pages. It is mostly devoted to coupling circuits, and this part is extremely well done, the subject being viewed from a practical angle and taking into account the requirements of ganged tuning.

R.F. amplification is next dealt with. The author starts with the impedance characteristic of a resonant circuit, goes on to discuss the characteristics of coils and the effects of screening, and then treats the various circuits commonly used, including band-pass types. The effect of curvature of the valve curves in producing distortion and cross-modulation is dealt with, as also are valve and circuit noise. The particular problems of short-wave amplifiers are also discussed.

Chapter 5 is devoted to frequency changing and is much more complete than one usually finds. The factors which result in the production of unwanted frequencies are explained and common image suppression circuits are discussed. Oscillators are next treated. All the common circuits are analysed and here occurs one of the few misprints in the book. On page 254 the last equation should be $G + jB$ not $+GjB$. The important question of frequency stability is treated at some length as well as both two-point and three-point tracking methods.

Detection is very fully discussed, beginning with the ubiquitous diode. The treatment is sound and includes the effect of both positive and negative bias. Grid and anode-bend detectors are dealt with as extensions of the diode, and the chapter concludes with a treatment of the apparent demodulation of a weak signal by a strong.

This volume concludes with two appendices—one on the "j" notation, and the other on Fourier series—and an index.

Throughout the book the treatment adopted is mathematical and extensive use is made of complex numbers. These are sufficiently explained in the appendix to enable anyone familiar with ordinary algebra to make use of them and to follow the equations. Although a quick glance through the book discloses many pages of equations, most of them are quite simple in form, and their presence should not deter anyone with a knowledge of elementary mathematics from using the book.

The book as a whole, or rather as a half, is very good and will be invaluable to the designer for reference. It includes a copious bibliography. It is well printed and bound and remarkably free from errors.

W. T. C.

The Technique of Radio Design

By E. E. Zepler, Ph.D. Pp. 311+xii. Chapman & Hall, Ltd., 11, Henrietta Street, London, W.C.2. Price 21s.

This book may help to bridge the gap between the learning of the fundamental physical theory of radio and the application of that theory in present-day technology; it could thus be of value to the University graduate who is just embarking on practical radio work in industry or the Services, and has yet to learn the tricks of the trade. The later chapter headings suggest a bias towards fault-finding (Chapters 9 to 12 deal with "Undesired Feed-back," "Hum, Spurious Beats," "Distortion," and "Parasitic Resonances") but the reason for this appears in the Preface: "The real technique of experimental work starts where unexpected complications occur, where a circuit behaves in a manner not readily predicted from its circuit diagram." In particular, the chapter on "The Principles of Screening" treats its subject very thoroughly, covering the question of holes and slots in screens, and the effect of circulating currents in chassis and screens due to multi-point earthing. Much of this chapter on screening increases in value and importance in proportion to the frequency at which the apparatus is working; though on the whole the book makes very little reference to frequencies higher than 30 Mc/s.

The book is compiled on severely practical lines, having no space for proofs or derivations of the formulae used, and all numerical formulae are given in practical units with factors of π, etc., combined into one numerical constant. It is undoubtedly a saving of time to have such quantities as inductance or capacitance per unit length and characteristic impedance of feeders expressed in terms of logarithms to base 10 instead of natural logarithms; but it is carrying the idea too far to quote the shot noise of a R.F. pentode as $I_n = k\sqrt{I_a \times \delta f}$ where $k = 0.4$ for a "typical" valve, because this k includes both a true constant $\sqrt{2e}$ and a variable factor commonly denoted by F, which varies from valve to valve. The reader who has not made a special study of noise may find difficulty in separating out these two factors so as to determine the actual value of noise for some particular valve for which a value of F may be given. Another useful practical feature is the presentation of the constants relating inductance to coil shape in the form of graphs, with both coordinates set to logarithmic scales.

The only indication that the author's experience was gained outside this country is the appearance of the expression "aerial and counterweight," instead of "aerial and counterpoise," and the author is to be congratulated on successfully transferring his experience into the English language. Britain is the richer for acquiring this experience, and it is to be hoped that we may one day have a companion volume on the design of radio components, a subject which is hardly touched in this book.

D. A. B.

Correspondence

Letters of technical interest are always welcome. In publishing such communications the Editors do not necessarily endorse any technical or general statements which they may contain.

"A Valve Oscillator Theorem"

To the Editor, "Wireless Engineer"

SIR.—There is one criticism of Dr. Emrys Williams's paper "A Valve Oscillator Theorem," in the October *Wireless Engineer* which may be worth making.

The tuned-anode and the Colpitts oscillators are treated as though they were essentially of different types.

Fundamentally, where the external circuit is composed of reactances, there are only two types of circuit possible for oscillation to occur. These are shown in Fig. 1.

Any other circuit arrangement can always be transformed into one or other of these arrangements.

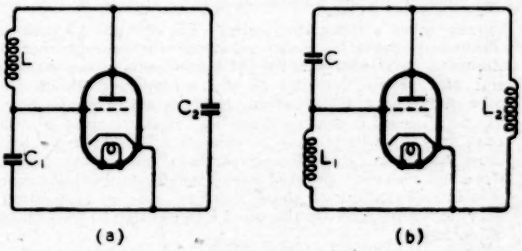
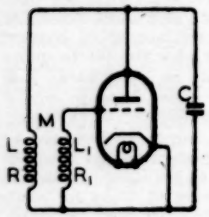


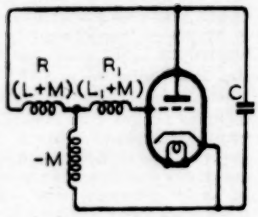
Fig. 1.

Let us consider the tuned-anode oscillator. This may be drawn as shown in Fig. 2 (a), which may be redrawn as Fig. 2 (b).

Now, since the grid input impedance is assumed to be infinitely high, the inductance adjacent to the grid may be ignored. Thus the equivalent circuit becomes that shown in Fig. 3.



(a)



(b)

Fig. 2 (*Above*).

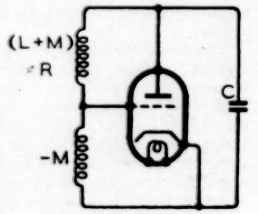


Fig. 3 (*Right*).

If now the circuit is treated as a Colpitts oscillator—a negative inductance being equivalent to a capacitance at a given frequency—and the values $Z_1 = -j\omega M$, $Z_2 = -j/\omega C$, $Z_3 = [R + j\omega(L + M)]$ substituted in equation (3) of the original article, it will be found that the conditions derived for the tuned-anode oscillator, by Dr. Williams, result.

Finally, the maintenance condition for the Colpitts oscillator should read:

$$Rr_a + L/C_2 = (1 + \mu)/\omega^2 C_1 C_2$$

W. P. N. COURT.

Malvern, Worcs.

Wave Guide Terminology

To the Editor, "Wireless Engineer"

SIR,—In a paper "Wave Guides in Electrical Communication," by J. Kemp given at a recent I.E.E. meeting the progression of waves in guides was pictured as a series of zig-zags from wall to wall down the guide, and the author referred to phase velocity as the velocity of a particular wave crest along the axis of the guide. This is greater than the velocity "v" of the crest along the zig-zag path, being $\frac{v}{\text{Cos }\theta}$ where θ is the angle at which the zig-zag wave strikes the walls. The mental picture so created appealed to me as excellent for presentation to students, particularly as the product of this phase velocity and the group velocity of the modulation down the tube equalled "v^2", and in the discussion I referred to an article on much the same lines in *Electronics*, March, 1943, p. 76, which gave a clearer mechanical analogy than Mr. Kemp's canal and sloping board. Dr. Smith-Rose has, however, pointed out to me the dangers of taking this interpretation of phase velocity, and in case others may be tempted to use the term I would like to pass on his objections.

There is an already existing definition of phase velocity; it is the velocity of a crest in the actual direction of travel of the wave, i.e., the zig-zag in the case of the guide, and this velocity only changes when the dielectric constant changes. In a non-dispersive medium having a fixed dielectric constant (such as the air inside the guide) there can be no actual change of phase velocity with change of frequency as occurs if the term phase velocity is applied to the crest velocity along the axis of the guide. This difficulty can be overcome by referring to the velocity of the crest down the guide as the equivalent phase velocity of the resultant wave. A more seriou sobjection is, however, that confusion may arise when considering wave guides in relation to normal propagation involving the direct ray and a series of indirect rays, which ricochet between the ionosphere and earth in much the same way as the zig-zags in the wave guide. These indirect rays suffer actual phase velocity change as they pass through the dispersive medium of the ionosphere. If the guide interpretation of phase velocity is employed the actual phase velocity change in the ionosphere is pushed into the background and one finds oneself with a number of direct rays of varying phase velocity because, by analogy with the guide, the reference level for phase velocity is the curve following the earth's surface between transmitter and receiver.

The advantages of using the term phase velocity with reference to the direct path between sending and receiving end are therefore outweighed by the difficulties they may create for a student already familiar with normal propagation theory.

K. R. STURLEY.

Chelmsford, Essex.

[The above letter from Dr. Sturley raises an important point. The subject of wave-guides was discussed in the Editorial of March, 1942, where we showed how the phase of the interference pattern moved axially along the tube at a velocity $v/\cos\theta$, whereas the energy or group velocity along the tube was $v \cos \theta$, so that their product was equal to v^2. The objection raised by Dr. Smith-Rose to referring to this phase velocity of the interference pattern as the phase velocity of the wave is well justified. It would certainly lead to some confusion if the wave-guide contained an ionised vacuum.—G. W. O. H.]

Index to Abstracts

THE index to the Abstracts and References section for Vol. XX, Jan.—Dec. 1943, which, as already announced, is in course of preparation, will be published in February.

Our Publishers again ask us to stress that, as supplies will be limited, it will be necessary for those requiring copies to make early application. A charge of 2s. 8d. (including postage) will be made for the index.

Institution of Electrical Engineers

THE subject to be discussed at the next meeting of the Wireless Section of the I.E.E., which will be held on January 18th at 5.30, will be "Comparative Merits of Different Types of Directive Aerials for Communications." The discussion will be opened by J. A. Smale.

Institute of Physics

THE Electronics Group of the Institute of Physics will hold a joint meeting with the Midland Branch of the Institute at the University, Edmund Street, Birmingham, on Saturday, January 22nd, at 2.30. A discussion on "Space-Charge and Noise in Radio Valves" will be opened by Drs. P. B. Moon and R. R. Nimmo.

Wireless Patents

A Summary of Recently Accepted Specifications

The following abstracts are prepared, with the permission of the Controller of H.M. Stationery Office, from Specifications obtainable at the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1/- each

ACOUSTICS AND AUDIO-FREQUENCY CIRCUITS AND APPARATUS

555 118.—Sound reproduction by utilising a surface layer having variable light-polarising properties.
International Polaroid Corporation. Convention date (U.S.A.), 10th September, 1940.

555 334.—Push-pull L.F. amplifier fed from a single input and arranged so that negative feed-back is applied only to the valve taking the input voltage.
The British Thomson-Houston Co., and J. Moir. Application date, 13th June, 1942.

555 523.—Bridge-stabilised oscillator capable of generating a number of different frequencies, particularly for controlling Multiplex telephony systems.
Standard Telephones and Cables (assignees of L. A. Meacham). Convention date (U.S.A.), 31st December, 1940.

DIRECTIONAL WIRELESS

555 052.—Equipment for ascertaining the position and following the movement of mobile craft by means of reflected radio waves.
H. F. Rost; K. M. Taunell; S. D. Vigren; and P. H. E. Claësson. Convention date (Sweden), 10th January, 1940.

555 206.—Direction-finding system of the kind in which two parallel frame aerials are mechanically connected together for rotation about a common centre, wherein means is provided for distinguishing between phase and amplitude minima.
R. J. Kemp. Application date, 4th February, 1942.

555 225.—Method of winding and mounting the stator coil of a radiogoniometer so as to facilitate access to the various parts for repair.
Standard Telephones and Cables (communicated by International Standard Electric Corporation). Application date, 27th February, 1942.

RECEIVING CIRCUITS AND APPARATUS

(See also under Television)

554 801.—Means for preventing undesired coupling between the elements of a ganged pair of variable condensers used for ultra-short-wave tuning.
Kolster-Brandes and D. N. Corfield. Application date, 16th January, 1942.

554 914.—Frequency-dividing circuit for shifting the frequency of a desired signal away from an undesired or interfering frequency.
Standard Telephones and Cables (assignees of R. La R. Miller). Convention date (U.S.A.), 24th April, 1941.

555 150.—Permeability-tuned set of coils for maintaining a constant frequency difference between the signal and local oscillator in a superheterodyne receiver.
Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date, 30th January, 1942.

555 212.—Ultra-short-wave signalling system with provision for reducing distortion due to the waves taking diverse paths, owing to reflection.
Marconi's W.T. Co. (assignees of C. W. Hansell). Convention date (U.S.A.), 7th February, 1941.

555 253.—Automatic gain-control system for an amplifier wherein the control element is a thermo-sensitive impedance.
Standard Telephones and Cables (assignees of H. S. Black). Convention date (U.S.A.), 25th July, 1941.

555 357.—Limiter circuit arranged to prevent distortion from occurring prior to the limiting level.
Marconi's W.T. Co. and T. H. Price. Application date, 16th January, 1942.

555 403.—Means for suppressing background and inter-channel noise when tuning a receiver for frequency-modulated signals.
The British Thomson-Houston Co. Convention date (U.S.A.), 20th August, 1941.

555 493.—Circuit for developing a control voltage which varies in accordance with the level of an A.C. input, particularly for A.V.C. in radio receivers.
Standard Telephones and Cables and C. T. Scully. Application date, 20th February, 1942.

555 526.—Constant feed-back circuit for regulating a receiver of frequency-modulated signals.
Standard Telephones and Cables (assignees of J. G. Chaffee). Convention date (U.S.A.), 13th November, 1940.

555 601.—Circuit arrangement, including a cathode load, for neutralising the inter-electrode capacitance in a high-frequency amplifier. [Addition to 534 531.]
The British Thomson-Houston Co. (communicated by General Electric Co.). Application date, 2nd September, 1942.

TELEVISION CIRCUITS AND APPARATUS

FOR TRANSMISSION AND RECEPTION

554 935.—Means for feeding the "message" sheet or blank to the rotating cylinder of a facsimile telegraphic transmitter or receiver.
Creed and Co. (assignees of R. J. Wise; G. H. Ridings; and R. D. Parrott). Convention date (U.S.A.), 18th April, 1941.

555 167.—Colour television system in which a number of images are converged by separate lenses on to a common viewing screen.
J. L. Baird. Application date, 13th May, 1942.

555 169.—Television or like signalling system in which the operative band-width is maintained constant by automatically compressing the wide-band parts and expanding the narrow-band of the signal.
Standard Telephones and Cables (assignees of R. E. Graham). Convention date (U.S.A.), 17th January, 1941.

555 179.—Colour television system in which the different coloured images are cyclically transmitted over a single signal channel, and in which provision is made for varying the colour balance.
Hazeltine Corporation. Convention date (U.S.A.), 2nd May, 1941.

555 213.—Colour television transmitter in which means are provided for removing residual charges from the mosaic screen after each scanning sweep.

Marconi's W.T. Co. (*assignees of E. I. Anderson and A. Barco*). *Convention date* (*U.S.A.*), *11th February*, 1941.

555 492.—Television receiver in which the line and frame synchronising signals are separated by appropriately tuned relaxation oscillators.

Standard Telephones and Cables; P. K. Chatterjea; and D. M. Ambrose. Application date, 20th February, 1942

555 565.—Colour television system in which the charges set up on a photo-electric mosaic are discharged by incident light of two different colours.

Marconi's W.T. Co. (*assignees of O. H. Schade*). *Convention date* (*U.S.A.*), *31st January*, 1941.

TRANSMITTING CIRCUITS AND APPARATUS

(*See also under Television*)

554 751.—Amplitude modulating device comprising a thermally-sensitive element responsive to the combined intensity of the carrier and signal currents.

Standard Telephones and Cables (*assignees of L. W. Hussey*). *Convention date* (*U.S.A.*), *8th April*, 1941.

554 836.—Frequency-discriminating bridge or network suitable for frequency modulation or for stabilising the wavelength of a radio transmitter.

The British Thomson-Houston Co. Convention date (*U.S.A.*), *17th January*, 1941.

554 887.—Variable-reactance network comprising two parallel tuned circuits, designed to operate as a frequency modulator.

The General Electric Co. and G. T. Thompson. Application date, 22nd June, 1942.

555 005.—Method of using a discharge tube of the velocity-modulating type for generating amplitude-modulated signals.

Standard Telephones and Cables (*assignees of C. V. Litton*). *Convention date* (*U.S.A.*), *28th January*, 1941.

555 008.—Means of calibrating the master oscillator of a wireless transmitting station.

Marconi's W.T. Co. and H. J. H. Wassell. Application date, 27th January, 1942.

555 232.—Method of using " side tone " in order to allow an operator to monitor transmitted speech so as to prevent over modulation.

J. W. Dalgleish and Pye. Application date, 3rd April, 1942.

555 307.—Facsimile telegraph system particularly designed for signalling between an aircraft and ground.

Creed and Co. and A. E. Thompson. Application date, 6th June, 1941.

555 323.—Construction and arrangement of the fins and ducts of a device for cooling, say, the anode of an electron-discharge device.

Marconi's W.T. Co. and A. J. Young. Application date, 10th February, 1942.

555 384.—Radio transmitter in which Class C amplifiers are " phase-swung " in order to ensure maximum efficiency in operation.

Marcovi's W.T. Co. and T. H. Price. Application date, 16th January, 1942.

SIGNALLING SYSTEMS OF DISTINCTIVE TYPE

554 911.—Terminating network for coupling a two-wire to a four-wire line, say, in a balanced carrier-wave signalling system.

Standard Telephones and Cables (*communicated by Western Electric Co., Inc.*). *Application date, 14th May*, 1942.

555 020.—Method of automatic gain-control for a signalling system utilising pulse modulation.

Standard Telephones and Cables (*assignees of A. L. Matte*). *Convention date* (*U.S.A.*), *19th February*, 1941.

555 458.—Selective relay system responsive to code signals such as are used in printing telegraphs.

Standard Telephones and Cables (*assignees of J. T. Neiswinter*). *Convention date* (*U.S.A.*), *26th June*, 1941.

555 476.—Remote control system in which radio-frequency signals operate a mechanism through a superheterodyne receiver which prevents " hunting " or over running.

AGA-Baltic Radio Akt. Convention date (*Sweden*), *6th September*, 1939.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

554 828.—Arrangement of the cathode and gun structure in an electron-discharge device for producing a directed beam of electrons.

Philips Lamps (*Communicated by N. V. Philips' Gloeilampenfabrieken*). *Application date, 17th November*, 1941.

554 851.—Discharge tube in which the electrons are coerced to travel in curved paths from the cathode to a target for generating or amplifying ultra-high frequencies.

Standard Telephones and Cables (*communicated by Western Electric Co., Inc.*). *Application date, 28th March*, 1942.

554 977.—Electrode arrangement of a diode designed to rectify ultra-short waves.

Philips Lamps (*communicated by N. V. Philips' Gloeilampenfabrieken*). *Application date, 18th December*, 1941.

555 015.—Magnetic focusing coils for controlling the field inside a cathode-ray tube or other electron-discharge device.

Standard Telephones and Cables (*assignees of B. M. Oliver*). *Convention date* (*U.S.A.*), *10th January*, 1941.

555 162.—Arrangement of an external resonant circuit in an electron-discharge tube of the velocity-modulating type.

Standard Telephones and Cables (*communicated by Western Electric Co., Inc.*). *Application date, 28th March*, 1942.

555 231.—Construction of an electron gun for producing a hollow electron stream of large intensity for a given accelerating voltage.

Standard Telephones and Cables (*assignees of A. E. Anderson*). *Convention date* (*U.S.A.*), *29th March*, 1941.

555 478.—Electrode assembly of a high-frequency amplifier when an anode and a control electrode are arranged on opposite sides of an openwork cathode.

G. Liebmann and Cathodeon. Application date, 20th November, 1941.

SUBSIDIARY APPARATUS AND MATERIALS

554 787.—Method of cutting a piezo-electric crystal so that it will oscillate in various modes which are substantially uncoupled and independently controllable.
Standard Telephones and Cables (assignees of W. P. Mason). Convention date (U.S.A.), 23rd May, 1941.

554 788.—Method of cutting and mounting a piezo-electric crystal so that it may be simultaneously excited at two uncoupled extensional modes, parallel respectively to the length and width of the crystal.
Standard Telephones and Cables (assignees of W. P. Mason). Convention date (U.S.A.), 9th May, 1941.

554 789.—Method of mounting and cutting a piezo-electric crystal so that it will vibrate simultaneously in a number of separately-controllable modes, at least one of which is flexural.
Standard Telephones and Cables (assignees of W. P. Mason). Convention date (U.S.A.), 22nd May, 1941.

554 790.—Network for exciting a piezo-electric crystal to a flexural mode of oscillation at a comparatively low frequency.
Standard Telephones and Cables (assignees of R. A. Sykes). Convention date (U.S.A.), 25th July, 1941.

554 808.—Thermionic valve circuit for deriving a lower frequency from the standard mains supply.
J. C. Arnold (communicated by The W. S. Tyler Co.). Application date, 31st July, 1942.

554 822.—Process for preparing the " blocking layer " of a dry-contact rectifier of the selenium type.
The British Thomson-Houston Co. Convention date (U.S.A.), 18th December, 1941.

554 892.—Construction and composition of an alternating-current rectifier of the selenium type.
Westinghouse Brake and Signal Co.; L. E. Thompson; and A. Jenkins. Application date, 21st January, 1942.

554 893.—Alternating current rectifier of the selenium type to which a proportion of sulphur is added to improve the ratio of " back " to " forward " resistance.
Westinghouse Brake and Signal Co.; L. E. Thompson; and A. Jenkins. Application date, 21st January, 1942.

554 894.—Alternating-current rectifier of the selenium type to which a proportion of antimony is added to improve the ratio of " back " to " forward " resistance.
Westinghouse Brake and Signal Co.; L. E. Thompson; and A. Jenkins. Application date, 21st January, 1932.

554 896.—Method of screening, balancing and stabilising an alternating-current bridge network used for precision measurements.
C. G. Mayo. Application date, 21st January, 1942.

554 959.—Arrangement of a thermionic valve voltmeter particularly for measuring the electrical characteristics of a circuit which is unbalanced to ground potential.
Standard Telephones and Cables (assignees of B. J. Kinsburg). Convention date (U.S.A.), 25th April, 1941.

554 963.—Method of cutting a piezo-electric crystal for simultaneous oscillation in a number of independently-controllable modes.
Standard Telephones and Cables (assignees of W. P. Mason). Convention date (U.S.A.), 10th June, 1941.

554 972.—Method of securing the connecting lead to the electrode of a blocking-layer rectifier.
Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date, 11th September, 1941.

555 078.—Multivibrator pair of cross-coupled valves with a common resistance in the anode feed for generating a square wave output.
H. W. Pratley. Application date, 13th May, 1942.

555 105.—Electromagnetic relay which, when once operated, is held in contact for a required period without the expenditure of a maintaining current.
Standard Telephones and Cables (assignees of W. A. Marrison). Convention date (U.S.A.), 29th May, 1941.

555 182.—Optical system for measuring the changes of dimension due to the effects of magneto-striction.
The British Thomson-Houston Co. Convention date (U.S.A.), 31st May, 1041.

555 196.—Apparatus for plotting equipotential lines or surfaces between two electrodes.
W. J. Jarrard; M. R. Moritz; and H. P. Zade. Application date, 28th August, 1941.

555 194.—Wave guide of rectangular cross section which is constructed to have sufficient flexibility to allow the direction of propagation to be changed gradually.
British Insulated Cables and J. C. Quayle. Application date, 10th July, 1941.

555 195.—Wave guide of rectangular cross section, and with metallised interior surfaces, which is made sufficiently flexible to permit a gradual change in the direction of wave propagation.
British Insulated Cables and J. C. Quayle. Application date, 10th July, 1941.

555 229.—Rectifier of the " trembler " or make-and-break type with means for controlling the frequency of the vibrating parts.
A. H. Stevens (communicated by Electronic Laboratories, Inc.). Application date, 18th March, 1942.

555 322.—Short-circuiting device for tuning a short-wave transmission line, without creating a " dead-end " effect.
Marconi's W.T. Co. and L. J. Golding. Application date, 10th February, 1942.

555 392.—Impulse-counting circuit comprising a number of gas-filled electron discharge devices which are severally operated.
Standard Telephones and Cables (assignees of F. E. Blunt). Convention date (U.S.A.), 20th June, 1941.

555 398.—Selective signal-response relay with provision to prevent false operation by parasitic surge frequencies.
The General Electric Co. and N. C. Smart. Application date, 22nd July, 1942.

Waste Paper

THE Waste Paper Recovery Association again draws attention to the necessity of separating salvage. " Foreign matter "—rubber, metal, etc.—in salvaged paper damages the pulping machinery and often results in tons of valuable paper being wasted.

GOODS FOR EXPORT

The fact that goods made of raw materials in short supply owing to war conditions are advertised in this journal should not be taken as an indication that they are necessarily available for export.

Abstracts and References

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For the information of new readers it is pointed out that the length of an abstract is not necessarily an indication of the importance attached to the work concerned. An important paper in English, in a journal likely to be readily accessible, may be dealt with by a square-bracketed addition to the title, while a paper of similar importance in German or Russian may be given a long abstract. In addition to these factors of difficulty of language and accessibility, the nature of the work has, of course, a great influence on the useful length of its abstract.

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PROPAGATION OF WAVES

1. Ultra-Short Electromagnetic Waves: I—Electromagnetic Theory.—E. Weber. (*Elec. Engineering*, March 1943, Vol. 62, No. 3, pp. 103–112.)

Already referred to in 2632 of 1943. "It has been attempted to present in a few pages material that is usually covered in volumes . . ." Transition from circuit concepts to the general field concept ("many unpleasant surprises are due to the assertion of the induced dielectric field at high frequencies": case of the capacitor with diameter comparable with the wavelength): uniform plane waves in a pure dielectric: energy transport in the uniform plane wave; uniform plane waves in conductors: boundary conditions on the electromagnetic field: reference books.

2. Equivalent Circuits to Represent the Electromagnetic Field Equations.—G. Kron. (*Phys. Review*, 1st/15th Aug. 1943, Vol. 64, No. 3/4, pp. 126–128.)

"It is known that for certain electromagnetic waves some of the characteristics of the wave propagation may be correctly described in terms of distributed inductances, capacitances, and resistances . . . For static fields . . . the field distribution itself may be related to current or voltage distribution in a network of similar circuit elements. The general relation between electromagnetic waves and distributed-constant networks has apparently not been investigated. The extent to which such networks may represent characteristics of various waves, or indeed space in general as a medium for the propagation of any wave distribution, is apparently not known and is of considerable importance. This has suggested that attempts be made to represent Maxwell's equations directly by equivalent circuits." Thus the network of Fig. 1 represents a charge-free space of permeability μ, dielectric constant ϵ, and conductivity σ. The values of the impedance elements forming the network depend only on these constants and on the size of the infinitesimal cube of space being replaced, so that the network represents space rather than any particular wave mode or frequency; the latter, as in reality, being determined by the boundary conditions. For two-dimensional cases ($\partial/\partial u_2 = 0$) the three-dimensional network separates into two independent networks lying in one plane (Fig. 2). Other equivalent networks will be the subject of a later paper.

3. "Idee und Begriff der Welle" [a Guide to the Writer's Fundamental Researches on Waves (*see* for example 1732 of 1935 and back references): Book Review].—K. Uller. (*Hochf:tech u. Elek: akus.*, April 1943, Vol. 61, No. 4, p. 128.) The author ends: "It is, however, the physics of the Future. To those who know only field equations and boundary conditions, it will be a closed book." The reviewer (Zenneck) fears that these will include the great majority of physicists.

4. The Types of Height/Frequency Characteristics of the Ionosphere.—A. I. Likhachev. (*Hochf: tech. u. Elek:akus.*, May 1943, Vol. 61, No. 5, pp. 154–156.)

A long summary, with diagrams, of the Russian paper dealt with in 3197 of 1942. The summary includes an explanation of the E-layer terminology used in the paper: instead of the usual "normal" and "abnormal" layers the writer distinguishes (a) a "refracting", (b) a "reflecting", and (c) a "screening" E layer. Signals from (b) and (c) are referred to as *EO* and *EI* echoes respectively. "From the properties described it may be deduced that (a) represents the 'normal' layer and (b) and (c) the 'abnormal', (b) standing for the case of what Appleton calls 'weak abnormal ionisation' and (c) for the case of 'strong abnormal ionisation' . . . The 'screening' E layer causes a partial (Fig. 6) or extremely rarely a total (Fig. 7) screening of the higher layers, with a limiting frequency of over 5 Mc/s. Its *EI* echoes are observed most frequently (and at any time of day) during June to August; in September to January, more seldom, chiefly at the end of the night; and practically never in the spring. They may persist for up to three hours, and are often accompanied by multiple reflections, even in daytime."

The effects spoken of in (9) of abstract 3197, called here

"pulsating echoes," are explained by Störmer's statement that at heights up to 1000 km the aurora occurs in a "strongly changing form." Regarding (8), changes in ultra-violet radiation and in atmospheric pressure are liable to produce new ionisation maxima between the E and F layers (Fig. 14) which are only noticeable in winter: in summer they are probably concealed owing to the high attenuation in the lower layers and the small amplitude of the echoes from the intermediate layers. Finally, the particularly high energy-loss in the passage of a wave at the special frequency of about 1.5 Mc/s is called on to explain why in September 1939 (four times), October (once: Fig. 15), and November (once), the F echo showed a strong absorption on 1.5 Mc/s, while the E-layer echo maintained a normal amplitude: in the frequency range from 1.5 to 2 Mc/s the reverse condition was observed.

5. "Swish" of the Aurora.—D. W. Rosebrugh. (*Journ. Roy. Astron. Soc. Canada*, No. 6, Vol. 37, 1943, p. 254 onwards.)

6. Presence of the Lyman Bands System of the Nitrogen Molecule in the Ultra-Violet Radiation of the Night Sky [and a New Formula replacing the Birge–Hopfield Formula].—L. Herman. (*Comptes Rendus* [Paris], 7th/21st Dec. 1942, Vol. 215, No. 23/25, pp. 527–529.) *Cf.*, for example, Déjardin, 1609 of 1942.

7. Theory of Cosmic-Ray Mesons [Quantum Theory of Damping (233 of 1943) applied to Production of Mesons by Proton/Proton Collisions (practically All in Top Layer of Atmosphere of Thickness 15–30 cm H_2O): Theory gives Satisfactory Account of All Chief Cosmic-Ray Phenomena].—J. Hamilton, W. Heitler, & H. W. Peng. (*Phys. Review*, 1st/15th Aug. 1943, Vol. 64, No. 3/4, pp. 78–94.)

8. On the Radiation from the Sun in the Far Ultra-Violet: I—Theory of the Chromospheric Eruptions.—K. O. Kiepenheuer. (*Zeitschr. f. Astrophys.*, No. 5, Vol. 20, 1941, p. 332 onwards: long summary in *Physik. Berichte*, No. 5, Vol. 23, 1942, pp. 659–660.)

"A very instructive survey of research results on solar radiation below 2000 AU, its production, action, and intensity": including a treatment of the Dellinger effect and a development of the writer's theory whereby the eruption is considered as a moving chromospheric-turbulence element brought to rest in a few seconds, on approaching a sunspot, by the latter's magnetic field, and giving up its whole kinetic energy as ultra-violet radiation.

9. Final Relative Sunspot-Numbers for 1942.—W. Brunner. (*Terr. Mag. & Atmos. Elec.*, Sept. 1943, Vol. 48, No. 3, pp. 161–162.)

10. The Severe Magnetic Storm of September 18th, 1941 [Alibag Records].—M. R. Rangaswami & A. S. Chaubal. (*Current Science* [Bangalore], Oct. 1941, Vol. 10, No. 10, pp. 432–433.)

11. Periodic Changes in ΔD at Oslo, 1843–1930 [11-Year Period: No Evidence of 8-Year Period in *Direct* Data: 8-Month Period, with Indications of an 8-Year Variation: Secular Variation].—K. F. Wasserfall. (*Terr. Mag. & Atmos. Elec.*, Sept. 1943, Vol. 48, No. 3, pp. 145–150.)

12. Three-Hour Range Index, K, at Dombås Observatory during 1939 to 1942 [including the 27-Day Recurrence Tendency], *and* American Magnetic Character Figure, Three-Hour-Range Indices, and Mean K-Indices, for April to June, 1943.—K. F. Wasserfall: H. F. Johnston. (*Terr. Mag. & Atmos. Elec.*, Sept. 1943, Vol. 48, No. 3, pp. 151–160: pp. 163–166.)

13. The Magnetic Character of the Year 1941.—J. Bartels. (*Terr. Mag. & Atmos. Elec.*, Sept. 1943, Vol. 48, No. 3, pp. 167–169: in German.)

14. Some Early Contributions to the History of Geomagnetism: IV—The Letter of Georg Hartmann to Duke Albrecht of Prussia, 1544: *and* Edmond Halley and Geomagnetism.—H. D. Harradon: S. Chapman. (*Terr. Mag. & Atmos. Elec.*, Sept. 1943, Vol. 48, No. 3, pp. 127–130: pp. 131–144.)

15. The Recombination Law for Weak Ionisation [Investigation to determine whether the Usual Law for Ions in a Pure Gas holds for Small Ionisation Values such as are found in the Lower Atmosphere].—P. J. Nolan. (*Terr. Mag. & Atmos. Elec.*, Sept. 1943, Vol. 48, No. 3, p. 185: summary only, by G. R. Wait, with comments.)

16. The Geophysicist as a Forecaster [Problems of Great Economic Importance amenable to Present Technique or Some Modification: including Weather Forecasting, particularly Fog: Number of Large Ions changes Some Hours before Formation of Fog (Phillips, 2078 of 1943): etc.].—P. Weaver. (*Geophysics*, July 1943, Vol. 8, No. 3, pp. 273–289.)

17. Preliminary Note on Condensation in the Form of Clouds and Dew [Preliminary Effort to Assess the Distribution of Drops according to Size, and so to Exhibit the Competition for Growth among the Drops].—J. W. Archbold. (*Phil. Mag.*, Sept. 1943, Vol. 34, No. 236, pp. 632–642.)

18. The Dielectric Constant of the Ground under "Electrolytic Condenser" Conditions: Values up to 10^{11} encountered in Field and Laboratory Tests.—Evjen. (In paper dealt with in 328, below.)

19. Some Effects of Geologic Structure [notably Contacts between Rocks of Different Composition, especially Fault Contacts] on Radio Reception.—Howell. (*See* 81.)

20. Transmission-Line Charts [Graphs for Computation of Voltage, Current, & Impedance Distribution for Any Point on Long Line, and for Any Termination producing Standing Waves].—R. F. Baum. (*Electronics*, July 1943, Vol. 16, No. 7, pp. 92–94 and 158.)

21. Distribution of Light Intensity within a Scattering Medium [Development of Integral-Differential Equation giving Intensity as a Function of Position & Direction: in Form suitable for Numerical Solution].—R. R. Newton. (*Journ. Applied Phys.*, Sept. 1943, Vol. 14, No. 9, pp. 481–486.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

22. Interference with Reception in Aircraft, due to Corona from Static Charges [American Experience with Cartridge Device against Precipitation Static (Hucke, 3065 of 1939: for earlier work *see* 1773 of 1938, and *cf.* 1821 of 1939): Failure, and even Added Danger, in Warm Air].—D. S. Little. (*E.T.Z.*, 25th Feb. 1943, Vol. 64, No. 7/8, p. 109: summary, from *Aero Digest*, 1941.) The abstractor remarks that in Germany a more

effective protection was found in 1938: Crone, Klumb, ref. " 2," and *see* 3122 of 1939.

23. REPORT ON APPLICATION OF LIGHTNING PROTECTIVE DEVICES IN WARTIME.—A.I.E.E. Subcommittee. (*Elec. Engineering*, Sept. 1943, Vol. 62, No. 9, Transactions pp. 586–588.)

24. THE PROTECTION OF BUILDINGS AGAINST LIGHTNING [Article based chiefly on Shipley's I.E.E. Paper of 6th May 1943].—J. F. Shipley. (*Engineering*, 17th Sept. 1943, Vol. 156, No. 4053, p. 232.) *See* also 1839 & 3279 of 1943.

25. " ÜBER DIE MÖGLICHKEIT DER VERBESSERUNG DES KLYDONOGRAPHEN DURCH DIE VERMINDERUNG DES DRUCKES " [Possibility of Improving the Klydonograph by a Reduction of the Pressure: Book Review].—F. Kurth. (*E.T.Z.*, 3rd June 1943, Vol. 64, No. 21/22, p. 309.)

26. THE RECOMBINATION LAW FOR WEAK IONISATION.—Nolan. (*See* 15.)

PROPERTIES OF CIRCUITS

27. EQUIVALENT CIRCUITS TO REPRESENT THE ELECTROMAGNETIC FIELD EQUATIONS.—Kron. (*See* 2.)

28. ELECTRICALLY " SMOOTH " CONSTRUCTIONAL ELEMENTS OF CONCENTRIC LINES AT HIGH FREQUENCIES.—H. Meinke. (*Hochf:tech. u. Elek:akus.*, May 1943, Vol. 61, No. 5, pp. 145–151.)

" After the load resistance (often at considerable cost) has been carefully matched to the characteristic impedance of the line, it is of course essential that the line system itself should be free from reflection-points, which would once more result in standing waves. There is no difficulty in designing a sufficiently uniform line of constant cross-section, but constructional elements are liable to occur, particularly at junctions, which spoil the uniformity. The present work considers the following examples of such elements: dielectric supports [for the central conductor], enlargements of cross-section, and angle-pieces. These points of irregularity are treated as quadripoles (Schmidt, 1933 Abstracts, p. 222: Meinke, 1853 of 1941: Weissfloch, 711 of 1943). They will refrain from producing stationary waves only if they are symmetrical and if their characteristic impedance at the appropriate frequency is equal to that of the associated lines.

" A measuring method for determining the electrical properties of such elements is given [Section 1]. An arbitrary, loss-free quadripole requires, for such determination, three characteristic values, which can be derived in very different ways according to the purpose in view [Feldtkeller's book, 2085 of 1943, is referred to here]. A treatment particularly suitable for quadripoles has already been given by myself [Meinke, *loc. cit.*]. The representation recently developed by Weissfloch [*loc. cit.*] (on the basis of his ' transformation law '), with its corresponding measuring technique, is identical as regards its contents with my earlier method (Weissfloch, 2084 of 1943 [where however the writer maintains that there is an important difference]). The quadripoles considered in the present work are special in so far that in the pass-band region they form only symmetrical quadripoles: these make a simpler representation possible, which renders the physical results more comprehensible on the lines of long-wave technique.

" The measurement of the quadripole properties with the help of ' node displacements ' is originally derived from Schmidt [*loc. cit.*]. All constructional elements which are accommodated so as to be electrically ' smooth ' over a wide range of frequencies have the form of low-pass filters with very high cut-off frequencies. All the examples given here refer to concentric lines without dielectric, of 70 ohms characteristic impedance. Naturally, they do not exhaust the possible range of application of the treatment (see later papers) ".

The section describing the " node-shift " measuring technique also includes the derivation of simple approximate formulae applicable to quadripoles whose " electrical length " is small compared with the wavelength: it ends by showing how the results of the measurements indicate how the quadripole should be " corrected ": such a " corrected " element is then suitable for use at all frequencies sufficiently removed from the cut-off frequency.

Section II considers insulating supports for the central conductor. " The behaviour of an individual support in a parallel-wire system has been investigated by measurements by Schmidt (*loc. cit.*) and Lange (435 of 1942), and for a concentric line by Weissfloch (Fig. 3: 711 of 1943 [no reference is made to Weissfloch's later work, dealt with in the long abstract 2083 of 1943: this must have appeared just as the present paper was sent in]. The action of a series of equal and equally-spaced supports was calculated by Buchholz (1302 of 1940), and the corresponding measurements were carried out by Riedel (2716 of 1943). The first attempts to construct supports whose capacitances should be ' smoothly ' compensated by additional inductances (Fig. 4 [where the size of the central conductor is suitably reduced as it passes through the dielectric disc]) were made known to me by E. Missler (ref. " 12 " [a Telefunken patent of Dec. 1941]). Suggestions of the same nature are contained also in Zinke's paper (in the press [and *see* also Riedel, *loc. cit.*]) . . . A satisfactorily strong and accurate support, whose dielectric consists of only a few silk threads impregnated with trolitul solution, was developed by Köhler (Fig. 2): only 0.5% of the space is occupied by dielectric, so that deviations of the characteristic impedance from the correct value are undetectable. The line must be divided at the point of insertion, since the outer and inner conductors form parts of the support. Such a silk-thread support serves for control measurements and for determining the true short-circuit plane of the short-circuiting slider, since it causes no displacement of the nodes". The simple disc support (Fig. 3) is dealt with first, and Table 1 shows the good agreement between calculations and measurements (on a 56 cm wave) for a 3.6 cm diameter, 1.2 cm thick, 1.12 cm aperture disc of trolitul, luvikan ($\epsilon = 3$) and iganil ($\epsilon = 3.5$) in succession: the right-hand column gives the matching error at $\lambda = 1$ m, calculated by eqn. 16. By such calculations it can be determined whether the simple support introduces only a tolerable irregularity for the frequency involved, or whether it must be " corrected " according to the plan shown in Fig. 4; either by reducing the size of the central conductor where it passes through the disc, or by recessing the outer conductor so as to accommodate a larger-diameter disc, or by both methods combined. Measurements for Z for $\lambda = 20$ cm (Table 3) show for a support of the Fig. 4 type the clear rise of Z with increasing frequency, in good agreement with the calculated values from eqn. 23. The equivalent circuit of Fig. 7 therefore gives an approximately correct picture of the behaviour of such a support. For all waves, therefore, over four times the length of the limiting wave given in eqn. 22 ($\lambda_o = \pi.l$, where l is the " electrical length " of the quadripole: impedance angle $\alpha = 2\pi l/\lambda$) a support can be constructed which is electrically " smooth," whatever the frequency. Measurements are thus necessary only at a single frequency. By the principle of similitude such measurements can be used also for the design of supports for lines of other diameters: this was confirmed by experiment.

Section III deals similarly with sudden expansions in cross-section, the ratio of the conductor diameters being kept constant. The resulting electrical irregularity can be represented as the effect of a subsidiary capacitance (shown in Fig. 8): with decimetric waves such a capacitance (of the order of 0.2 pF) cannot be neglected. The effect can be eliminated by displacing the expansion of the inner conductor with respect to that of the outer, as in Fig. 9 (ref. "15": Meinke, Telefunken patent): this not only decreases the capacitance but also produces an additional series inductance, giving a quadripole (Fig. 10) which, for a suitable choice of the displacement a, has the same characteristic impedance as the line itself. Section IV deals with conical sections bridging the transition from one cross-section to another (*see* also Riedel, *loc. cit.*, towards end of abstract). Finally, Section V considers right-angled bends.

29. Resonance Condition, Oscillating Field Energy, Dissipative Loss, Damping Factor, and Frequency Variation of Cylindrical Concentric Cavity Resonators of Circular Cross-Section [with Curves for Practical Use].—W. Dällenbach. (*Hochf:tech. u. Elek:akus.*, May 1943, Vol. 61, No. 5, pp. 129–140.)

"In centimetric- and decimetric-wave technique, cavity resonators are applied to an ever-increasing extent for the construction of generators ('Resotank' oscillators) and also for other purposes. Because of their simple production, shapes with symmetry of rotation are frequently employed, particularly cylinders with circular cross-section. At the potential antinode of such a cylindrical concentric cavity resonator a concentrated capacitance C is often mounted, in whose field-space, for example, an electron flow passes which in the case of a generator excites the cavity oscillations or in the case of detector valves performs the rectification. Figs. 1–4 show some practically important forms in a systematic arrangement: thus in Figs. 1 and 2 the concentrated capacitance at the potential antinode is a plane condenser, in Figs. 3 and 4 it is a cylindrical one. Figs 1 and 3 are resonators with one current antinode, Figs. 2 and 4 have two. The types marked 'a' in each figure are all concentric-tube lines of diameter small compared to their axial length, and having their electric field perpendicular to the axis of rotation; those marked 'c', on the other hand, are circular boxes shallow compared with their external diameter, with their electric field parallel to the axis of rotation; while type 'b' are intermediate between these two extreme forms, and are the type practically always involved when cavity resonators are desired with minimum dissipative loss, or (cognate but not identical) with minimum damping. On the other hand both the forms 'a' and 'c' have a higher frequency-stability than 'b': as one moves from 'b' towards either 'a' or 'c', that component of the resultant capacitance K, in the neighbourhood of the potential antinode, which is due to the cavity itself and which is added to the fixed value C of the concentrated capacitance, increases in both cases. With it increases also (for a constant amplitude U_e at the potential antinode) the field energy $\frac{1}{2}KU_e^2$ in the resonator, and consequently also the frequency-stability.

"In practice it is often necessary to choose a suitable compromise between the mutually contradictory demands of maximum frequency-stability (types 'a' and 'c') and minimum losses or minimum damping (type 'b'). To do this it is necessary, for a given concentrated capacitance C and a given wavelength λ, to know the limits within which the dimensions of the cavity may be varied, and the behaviour, to such a variation, of the oscillating field energy F, the dissipative loss N, the damping factor h, and the frequency-variation $\delta\omega$ produced, for example, by the modulation of a generator."

Dealing first with the long, small-diameter "a" types of Figs. 1–4, the writer points out that by division along the cross-section x..x (mid-point of the cylindrical condenser) Fig. 4a yields two halves of the type of Fig. 3a, identical as regards F, N, h, and $\delta\omega$ with the form of Fig. 1a, provided that losses in the capacitance C are neglected, as is assumed. Fig. 2a, on the other hand, cannot be referred to Fig. 1a, owing to the absence of a metal separating wall in the x..x plane and the ohmic loss in such a wall: Fig. 2a therefore requires a separate treatment. For both Fig. 1a and Fig. 2a the resonance condition is given by eqn. 5 and the curve family of Fig. 5: for Fig. 1a F is given by eqn. 7, and for Fig. 2a it is double this value. For both Fig. 1a and Fig. 2a N is obtained by eqns. 8–13 which deal with the various components making up N. All these formulae involve U_e, the peak value of the potential at the concentrated capacitance, and the next step is to obtain expressions independent of this quantity. This is done in eqns. 14–24, and Figs. 6–13, derived from these, show curve families (for types 1a and 2a) giving F, N, h, and $\delta\omega$ as functions of the ratio z of the tube radii, with parameter g ranging from 0 to 0.50: g being a real number (the capacitance factor) equal to $C/d\lambda$ (eqns. 4, 5).

The shallow-box types, "c" of Figs. 1–4, are then dealt with similarly, and Figs. 14–20 give the corresponding curve families. Then the final section III shows, by an example, how the intermediate forms (type "b") between the concentric tubes and the shallow boxes can be dealt with by interpolation, by graphic means, between the results for the two extreme types. Or the tube and box curves of Figs. 21–25, drawn for this purpose for the case in point, could be combined with a large number of experimental measurements to yield empirical formulae for such interpolations. A note added while the paper was in the press refers to Meinke's work (685 of 1943) "in which the treatment of similar problems is begun."

30. Practical Observations on the Frequency-Stabilising Action of Spherical Cavities.—K. F. Niessen. (*Physica*, Vol. 9, 1942, p. 768 onwards.)

31. Transmission-Line Equations [Correspondence on 717 of 1943].—P. d'E. Stowell: C. G. Carrothers: Cissna. (*Elec. Engineering*, March 1943, Vol. 62, No. 3, pp. 138–139.)

32. Transmission-Line Charts.—Baum. (*See* 20.)

33. Chart for determining the Square Root of a Complex Number [in Transmission-Line & Filter Calculations].—R. G. Nisle. (*Electronics*, Aug. 1943, Vol. 16, No. 8, pp. 127 and 128.)

34. Historic Firsts: Wave Filters [G. A. Campbell's 1917 Patent].—(*Bell Lab. Record*, Aug. 1943, Vol. 21, No. 12, p. 445.)

35. On the Design Calculations of Bridge-Type Filters for Prescribed Operative Attenuation.—H. Wucherer. (*T.F.T.*, April 1943, Vol. 32, No. 4, pp. 89–95.)

"In calculating the circuit components of simple bridge-type filters by the method most convenient for the communications engineer (Feldtkeller's 'Siebschaltungstheorie'), not only the terminating resistance but also the cut-off frequencies of the circuit and the null-points and peaks of the operative attenuation curve are taken as given, and it is then examined whether the shape of the frequency characteristic thus obtained satisfies the requirements which have been set." As a rule this cannot be expected straight away, since the generally prescribed

values for the attenuations in the pass-band and the regions on either side of it are such as to demand a quite definite relation between null-points, cut-off frequencies, and peaks. "For bridge-type filters with two null-points and two peaks of the operative attenuation there are results of investigations already available on this point (Feldtkeller & Rheinhard, 3272 of 1941). In the present paper we propose to extend these investigations to the remaining cases of practical importance, and to derive formulae and curves for the calculation of the components of these bridge-type filters."

The writer's treatment is based on that of Feldtkeller and his use of the "choking factor" (Drosselungsgrad : $\sqrt{e^{2b_B}-1}$) to investigate the course of the operative attenuation b_B of a four-terminal network. This is represented throughout by D, and the relation $b_B = \frac{1}{2}\log_e(1+D^2)$ is used to give the attenuation. After consideration of the basic circuit of Fig. 1 (which represents a simple low-pass filter but the analysis of which can easily yield, by frequency transformation, results applicable to high-pass, band pass, and band-stop filters) he deals with circuits with monotonically rising operative attenuation, circuits with balanced pass-attenuation and monotonic rise of attenuation in the cut-off zone, circuits with singly balanced pass-attenuation and singly steepened cut-off attenuation, and (for specially high requirements as to the rise of the cut-off attenuation) circuits with doubly balanced pass-attenuation and doubly steepened cut-off attenuation. For each case he considers the requirements in accuracy for the circuit components, which are seen to became more and more stringent as the performance requirements are heightened : with the result that he concludes that circuits with two null-points and two peaks in the operative attenuation represent about the limit for a reliably functioning filter—a result which agrees with practical experience.

36. An Electric Filter giving at Will either One or Two Pass-Bands.—M. Parodi. (*Comptes Rendus* [Paris], 7th/21st Dec. 1942, Vol. 215, No. 23/25, pp. 572–573.)

A series of identical circuits, without resistance, each coupled by the same mutual inductance M, constitutes a band-pass filter. It is shown that if two identical systems of this type, assumed to be infinite and without resistance, are arranged in parallel in such a way that the mutual inductance between any two circuits of the same rank has a constant value M', then if $M' < 2M$ the whole arrangement acts as a band-pass filter with a width of band exceeding that of either filter-chain separately, while if $M' > 2M$ it possesses two pass-bands. By varying M' it is thus possible to obtain either result, and also, within certain limits, to vary in each case the cut-off frequencies. Similar considerations can be developed for low-pass and high-pass filters.

37. The Two Most Important "Tone-Diaphragm" Circuits [Simple Low-Pass Filters for A.F. Amplifiers].—de Gruyter. (*See* 90.)

38. Introduction to Four-Terminal-Network and Filter Theory on Elementary Foundations : Part I—Laws and Properties of the Four-Terminal Network [First of a Series intended for the Practical Designer].—E. Hameister. (*Zeitschr. f. Fernmeldetech.*, 20th May 1943, Vol. 24, No. 4/5, pp. 49–55.)

39. "Fundamental Principles of Electric and Magnetic Circuits" [Book Review].—F. A. Fish. (*Phil. Mag.*, Sept. 1943, Vol. 34, No. 236, p. 650.) "The student who uses it will find that he has nothing to unlearn when he comes to study the higher branches of power machinery and transmission."

40. Graphic Solutions of Ohm's Law for A.C. Networks.—R. C. Paine. (*Electronics*, June 1943, Vol. 16, No. 6, pp. 232..250.) "Vector diagrams showing voltages, impedances, and current are numerous in electrical text books, but they seldom show all these elements integrated in complete solutions. Several such complete graphic solutions are presented here."

41. Comparison of the Transform and Classical Methods.—B. K. Hovey : Lyon. (*Elec. Engineering*, Sept. 1943, Vol. 62, No. 9, p. 428.)

Letter prompted by Lyon's article, 2676 of 1943, which includes "a valuable interpretation of the problem of solving transients in electrical networks in the general case when the curents have initial values and there are initial charges on the condensers." Discussing methods of locating complex roots, particularly by contour plotting, Hovey remarks that so far as he has been able to determine the possibility of employing synthetic division to evaluate points on these contours has been overlooked completely : he describes the procedure.

42. Design for Dissymmetrical T Pads [Graphs for Attenuations up to 25 db and Impedance-Mismatch Ratios up to 5 to 1 : equally Useful for Symmetrical Pads for matching Equal Impedances].—E. Y. Webb, Jr. (*Electronics*, July 1943, Vol. 16, No. 7, pp. 123–124.)

43. A Delay Element for the Uniform Delaying of a Wide Frequency-Band.—Roosenstein. (*See* 137.)

44. Radio Data Charts : No. 12—Inductance, Capacity, and Frequency : Short Wave.—J. McG. Sowerby. (*Wireless World*, Nov. 1943, Vol. 49, No. 11, pp. 324–326.)

45. "Electrical Counting" [Book Review].—W. B. Lewis. (*Journ. Applied Phys.*, Sept. 1943, Vol. 14, No. 9, p. 466.)

A previous review was referred to in 1736 of 1943. "Should be read by every serious student of experimental physics and should be studied by every nuclear physicist and electronic-circuit man"; the circuits dealt with, from personal experience, include voltage-stabilisers, cathode-followers, trigger-circuits, and many others.

46. An Analysis of Oscillating Systems containing R and C [including Their Use as Sharply Resonant Circuits for Frequencies of a Few Cycles per Second].—V. I. Siforov. (*Izvestiya Elektroprom. Slab. Toka*, No. 10, 1940, pp. 4–16.)

A mathematical analysis is given of the operation of resistance–capacity-coupled amplifiers adapted for generating oscillations. The frequency of the oscillations, their stability in frequency and amplitude, the conditions for self-excitation, and the resonant properties of the circuit are discussed. It is shown that by making use of negative feedback it is possible to construct *RC* oscillators covering a very wide frequency-range (down to a few cycles or even parts of a cycle), possessing good frequency- and amplitude-stability and generating oscillations which are almost pure sine waves. The oscillators can also be used as tuned circuits with a very sharp resonance curve at frequencies of the order of a few cycles per second.

47. Power Output of A.C.-Operated Amplifiers [for Many Industrial Applications : Rapid and Comparatively Simple Graphical Methods of determining Power Output of Triode and Pentode

Amplifiers]. — W. A. Schwarzmann. (*Electronics*, Aug. 1943, Vol. 16, No. 8, pp. 94–96 and 277, 278.)

48. Amplification of Direct-Current Impulses, with Suppression of Amplifier Noise.—H. Köhler. (*E.N.T.*, March 1943, Vol. 20, No. 3, pp. 61–65.)

This work, together with that dealt with in 42 of 1942, was carried out during 1937 in the C. Zeiss laboratories. The present paper derives further relations between the frequency characteristics of an *RC* amplifier and the transient process, and applies these general relations to the particular problem of obtaining maximum amplification of the impulse combined with minimum amplifier noise : a problem of special importance when a relay, for instance, is to be actuated through the amplifier. The previous paper showed that a definite impulse-amplification could be obtained by combinations of very different values for the valve and circuit resistances and capacitances (Figs. 1, 2), that is, for different band-breadths of the amplifier : since the output noise-voltage is chiefly a function of this breadth, it must be possible to find an arrangement giving the optimum signal/noise ratio.

Author's summary :—" The equations for the frequency characteristic and the transient process of an amplifier stage are given in terms of quantities which can be taken from the frequency characteristic. Formal analogies thus emerge between the amplifier stage and an oscillatory circuit [thus eqn. 11 for the stage differs only from that for an oscillatory circuit in that the hyperbolic sine appears in place of the corresponding trigonometrical function : *see* also eqn. 9 and the text below it].

" Further, equations in closed form are derived from which it is seen how a ' low-noise ' impulse-amplifier must be designed. The parallel capacitances C_g and C_a, and also the ratio $C_k/(C_g + C_a)$ [Fig. 1 : C_k is the coupling condenser] must be made as large as possible. This involves a narrowing of the transmitted frequency-band and an increase of the delay-time. A linear increase of the factor-of-merit of noise [$G_{n\,\mathrm{noise}}$, the ratio $U_{n+1\,\mathrm{impulse}}$ to $U_{n+1\,\mathrm{noise}}$, obtained for a single-stage or a double-stage amplifier by dividing eqn. 15 or 16, respectively, by eqn. 20 or 21, respectively] thus involves a quadratic decrease in band-breadth and a quadratic increase in delay-time. The noise factor-of-merit of an amplifier is the better, the larger the number of stages possessed by the amplifier " [eqn. 34 for $G_{n\,\mathrm{noise}}$ involves a function ϕ_n, which is plotted against n, the number of stages, in Fig. 7 : the curve rises from 1.4 for 1 stage to nearly 3.0 for 7 stages. Physically, this behaviour is explained by the fact that the frequency-characteristic curves of Fig. 3 have their flanks steepened by an increase in the exponent in eqn. 3 : that is, by an increase in the number of stages].

The analysis of the frequency-characteristic of amplification, with which the paper begins, leads to the following three additions to the laws of transient processes :—(i) the delay-time is inversely proportional to the band-width and directly proportional to a correction factor which depends only on the relative band-width and increases monotonically with this (Fig. 5). (ii) The decay time-constant of the amplifier corresponds to the reciprocal half-band-width. (iii) The impulse amplification practically corresponds to the amplification coefficient in the pass band : the deviation from this is given by the correction factor $1 - \delta_1$ which, increasing monotonically with the relative band-width, tends towards unity (Fig. 6). For corrections to equations *see* May issue, p. 135.

49. Signal/Noise Ratio in Negative-Feedback Amplifiers [Letter on Macklem's Conclusions, 3316 of 1943 : Change of Circuit would give Different Results : Analysis].—J. T. Pratt : Macklem. (*Electronics*, June 1943, Vol. 16, No. 6, pp. 336..339.) *See* also W. Palmer, pp. 339, 340.

50. The Use of Negative Feedback in the A.F. Amplifiers of Broadcast Receivers.—Govyadinov. (*See* 91.)

51. Amplifier Circuit with Simultaneous Current and Voltage Negative Feedback.—E. Koch. (*Hochf:tech. u. Elek:akus.*, April 1943, Vol. 61, No. 4, p. 124, Fig. 3.)

An A.E.G. patent, D.R.P.726 042. To enable the internal resistance of the amplifier to be adjusted without affecting the amplification, the negative-feedback voltage is taken off a resistance R_k, which is traversed by the anode current and which has in parallel to it an alternating-voltage source controlled by the anode alternating voltage and in series with the adjustable resistance $\mathfrak{R}$ (this source is represented, for instance, by the transformer T). " The amplification is independent of the value of $\mathfrak{R}$ (which may be dependent on frequency) if the negative-feedback voltage developed at R_k and that delivered by the alternating-voltage source are equal."

52. Neutralised Wide-Band H.F. Amplifier with Two Valves in a Special Balanced-Bridge Push-Pull Circuit.—Philips Company. (*Hochf:tech. u. Elek:akus.*, April 1943, Vol. 61, No. 4, p. 125, Fig. 5.) Swiss Patent 220 883.

53. Powdered Iron Cores [and a Special Coupling Circuit (*e.g.* for Feedback Control) with Great Advantages].—Crossley. (*See* 224.)

54. Iron-Core Components in Pulse Amplifiers.—Lee. (*See* 139.)

55. On the Theory of the Magnetic [Polarised-Iron-Core] Amplifier [and the Superiority (as regards Wave-Form) of Parallel over Series Connection, the Similarities & Differences between These Amplifiers and Valve Amplifiers, etc.].—Th. Buchhold. (*Arch. f. Elektrot.*, No. 4, Vol. 37, 1943, p. 197 onwards.) A long paper on the hitherto neglected theory : *cf.* Geyger, 2857 of 1941.

56. Synchronising Controls of High Accuracy and Reliability.—P. Barkow & A. Lechner. (*E.T.Z.*, 25th Feb. 1943, Vol. 64, No. 7/8, pp. 108–109.) Another summary of the report dealt with in 2099 of 1943.

57. Multivibrators [Mode of Action treated by Mechanical Analogy : Applications].—P. C. Jones. (*Bell Lab. Record*, Sept. 1943, Vol. 22, No. 1, pp. 17–23.)

58. Single-Valve Frequency-Divider : Another Application of the " Transitron " or Negative-Transconductance Oscillator [Herold Oscillator : Analogy between This and the Franklin Oscillator (with Phase-Reversing Valve) : Removal of Tuned Circuit converts F.O. into Multivibrator, H.O. into Similar Arrangement : Use of " Untuned " H.O. as Frequency-Divider].—P. F. Cundy. (*Wireless World*, Nov. 1943, Vol. 49, No. 11, pp. 335–337.)

59. Negative Resistances, Their Properties and Effects : Sinusoidal Oscillations, Relaxation Oscillations, and Relaxation " Jumps."—W. Reichardt. (*E.N.T.*, March 1943, Vol. 20, No. 3, pp. 76–87.)

Author's summary :—" A certain distaste towards calculations on negative resistances is excusable. It is based first and foremost on the fact that there is no such

thing as a purely ohmic negative resistance. The inductive or capacitative character of these organs must always be sifted and taken into account at least qualitatively, and allowed for in the circuit connections. Next, under certain conditions instability phenomena appear which have no parallel in other fields of electrical engineering. Finally, no organs of the nature of negative resistances possess a constant value of resistance. The property of negative resistance holds good only within a limited range of current or voltage : outside this range other resistance values prevail, always positive in the end regions. The property of negative resistances can consequently never be defined unequivocally by giving a single, negative value, but is best expressed by furnishing a characteristic, the curve of the relation between current and voltage.

" If negative resistances thus display no such simple behaviour as positive resistances, it is nevertheless possible to give clear, simple, and generally valid rules as to their relations to other circuit elements. A distinction must be made between current-controlled, ' inductive ' negative resistances and voltage-controlled, ' capacitative ' negative resistances [Fig. 1 (example : series-wound generator) and Fig. 2 (example : dynatron), respectively]. Whether sinusoidal oscillations, relaxation oscillations, or ' kippsprünge ' [relaxation jumps] occur depends only on the nature of the load, for which a few quite elementary basic cases are given.

" The use of the negative resistance offers great advantages as a concept which covers a whole group of electrical organs and, in many cases, extremely complicated circuits ; for the basic behaviour of very different types of organ with negative resistance is always the same with regard to external loads. By collecting together the various rules it is possible to carry out a consistent grouping of the many phenomena associated with negative-resistance organs. For this grouping, the essential characteristic curve of negative resistance in question need only be determined as regards its *type*.

" An exact determination of the characteristic is, however, necessary if it is desired to find the curve shape, and the course in time, of relaxation oscillations or jumps. If the characteristic is analysed into parts which are, in themselves, linear, it is justifiable to employ the resistance value corresponding to the slope of a particular portion of the characteristic for comparison with the external resistances of the circuit, provided it is recognised that this operation is only valid for a limited current or voltage region. By this treatment it is possible, as has been shown in a previous paper (1931 Abstracts, p. 610 [*see* also 1932 Abstracts, pp. 91–92]), to obtain without much difficulty a comprehensive view of the very varied phenomena occurring in connection with negative resistances, and to determine unequivocally the curve forms for individual cases, without its being necessary to explore the internal mechanism of the circuit-complex producing the negative resistance."

Among special points of interest in the writer's treatment, his consideration of the instability conditions includes a warning of the danger in neglecting the Barkhausen " inertia criterion " : this has been done both by Friedländer and by Rothe & Kleen (refs. " 4 ", " 8 "). The former, for instance, considers a current-controlled inductive negative resistance loaded simply with a condenser, and a voltage-controlled capacitive type loaded simply with a choking coil : he thus arrives at stability conditions which do not occur in practice.

60. On the " Voltage-Utilisation Factor " of Some Surge-Generating Circuits [and the Superiority of the V.D.E. Standard Circuit " b "].—P. Paasche. (*E.T.Z.*, 3rd June 1943, Vol. 64, No. 21/22, pp. 295–297.)

TRANSMISSION

61. Ultra-Short-Wave Generation with a Cathode-Ray Tube having at least One Beam.—Philips Company. (*Hochf:tech. u. Elek:akus.*, April 1943, Vol. 61, No. 4, p. 124, Fig. 2.) Swiss Patent 220 882, applied for 16/4/1941 : a variant of the scheme dealt with in 2977 of 1943.

62. Generation of Ultra-Short Waves [by Velocity Modulation : the Classic Paper in *Zeitschrift für Physik*].—A. Arsenjewa-Heil & O. Heil. (*Electronics*, July 1943, Vol. 16, No. 7, pp. 164..178.) Translation of the paper dealt with in the long abstract 3380 of 1935.

63. Positive-Grid or Retarding-Field Oscillators [and Their Importance as Generators of Oscillations up to 5000 Mc/s : Survey, including Herschberger's Three-Sectioned-Plate Valve and Its Advantages (3330 of 1936)].—R. I. Sarbacher & W. A. Edson. (*Electronics*, Aug. 1943, Vol. 16, No. 8, pp. 108–111 and 232..244.) Condensation of a chapter from the book referred to 3335 of 1943.

64. Circuit for a Magnetron Transmitter with Alternative Wavelengths [Each in the Region of One of the Three Oscillation Modes (n = 1, 2, and More than 2), with Practically Unchanged Supply Conditions], *and* Circuit for Magnetrons working in Parallel.—G. Güllner & L. Müller : A. Lerbs. (*Hochf:tech. u. Elek:akus.*, April 1943, Vol. 61, No. 4, p. 124 : p. 124.) " Blaupunkt " patents, D.R.F. 726 588 & 726 673.

65. Electronic Oscillations of Higher Order in Split-Anode Magnetrons.—E. Djakov & A. Raev [Rajeff]. (*Hochf:tech. u Elek:akus.*, May 1943, Vol. 61, No. 5, pp. 140–145.)

Two main types of oscillation occur in the split-anode magnetron, the " Habann " type due to the statically measurable negative resistance and the " path-time " type in which the setting-up of oscillation depends on the non-quasistationary motion of the electrons. In this latter type, a distinction is made between those of the first or lower order (n equal to or less than unity) and those of higher order. It is these last for which Posthumus, Herriger & Hülster, Gundlach, Okabe, and Lämmchen & Lerbs have given their various interpretations of the mechanism involved : but the present writers point out that all these workers agree on one point, that the frequency of these path-time oscillations of higher order is determined by the associated oscillatory circuit.

From the authors' summary :—" The results reported in the present paper lead unequivocally to the conclusion that electronic oscillations of higher order exist, in the split-anode magnetron, which have never been observed before. With these oscillations the wavelength is determined by the equation $\lambda = K \cdot r_a^2 B/U_a$ and is independent of the anode circuit. There are two oscillations of this type, with different values of the constant K [K_1 = 700, K_2 = 400, for a four-slit magnetron, whatever its dimensions : for a two-slit magnetron the corresponding values are 1700 and 1100]. The first type, with wavelength λ_1, is more stable than the second, with λ_2. The two types also behave differently with respect to the angle between the magnetic field and the cathode, and to the emission current. From this it may be concluded that the two oscillations involve different electron mechanisms [in some cases a third oscillation, K_3 = 300 and 460 respectively, was observed, but was too weak to investigate further]. The presence of oscil-

lations when the anode current was smaller than 1 μ and with an aperiodic anode circuit shows than this oscillation mechanism functions even when the a.c. voltage between the segments is extremely small. . . ."

The top section of Fig. 4 shows how λ_1 and λ_2 behave as the length of the associated Lecher-wire system is increased from 10 to over 80 cm: both wavelengths remain constant except in the regions, B_1, B_2, of resonance between the two oscillation-frequencies and the Lecher wire frequencies, where the wavelength jumps to the curve of the natural wavelength of the external circuit and displays the oscillation-hysteresis effect encountered in coupled circuits. This behaviour indicates that the electronic oscillation forms a primary circuit and the anode circuit a secondary: similar relations are known in the retarding-field triode (*see* for example Wundt, 1931 Abstracts, pp. 94–95). A discussion of the new results leads to the conclusion that the previously known oscillations arise out of the ones here described, by resonance with the external circuit; the new oscillations, outside the resonance regions B_1, B_2, being so comparatively small in intensity that they have hitherto been missed. As to the actual mechanism, the obvious theory that the electrons give up energy to the anode circuit as they fly past the slits meets with the difficulty that similar oscillations occur in the whole-anode magnetron without any slits. A satisfactory theory must also account for the fact that the same two sets of oscillations (and sometimes the third) occur in the split-anode magnetron with different d.c. potentials on the segments; and even when half the segments are at some hundred volts or so of negative potential. This last case will be dealt with in a paper to appear shortly.

66. Very-High-Frequency Receiver Oscillator Design.—White. (*See* 77.)

67. Method of Stabilising the Frequency of Valve Oscillators.—L. Pungs. (*Hochf:tech. u. Elek:akus.*, April 1943, Vol. 61, No. 4, p. 124.)

D.R.P. 726 047. To eliminate the influence of supply-voltage fluctuations, screen-grid valves are used, with their s.g. and anode voltages tapped off a voltage-divider. In order that the voltage ratio most favourable to frequency constancy may be the same for all frequencies involved, tuning is accomplished by simultaneous variation of inductance and capacitance, in such a way that the anode-circuit resistance remains unchanged.

68. Transmitters with Multiple Retroaction-Channels.—R. Golicke. (*E.N.T.*, March 1943, Vol. 20, No. 3, pp. 65–76.)

The ordinary valve transmitter has only one retroaction path from the energy-supplying electrode through a tuning element to the control grid. For stabilising the amplitude by the non-linear properties of the valve, the oscillating grid is usually driven to the point of grid-current onset, or at the least over a large part of its characteristic, so that with such transmitters it is impossible to work with small alternating voltages in the retroaction channel. The result is that the frequency-governing element has to be able to convey large control voltages, and consequently the large powers necessary to provide such voltages in loss-producing circuit elements: it therefore generally takes the form of a high-resistance arrangement, such as a parallel circuit, a crystal oscillating in parallel resonance, or a resistance–capacitance circuit. This limitation to comparatively large control voltages is, among other things, adverse to the frequency-constancy of the transmitter, because the effects of varying components of the valve-capacitance on the frequency are bound to increase if, as a result of larger alternating voltages at the control grid, an appreciable part of the frequency-determining wattless current flows through this capacitance. Also, many particularly selective tuning arrangements, such as a crystal in the series-resonance connection between suitably low terminating resistances, cannot be employed; for these resistances, in order not to affect the sharpness of resonance of the crystal, should be small compared with the resonance resistance (amounting as a rule to a few hundred ohms only), and to produce high control voltages at such resistances would require energies which would overload the crystal. Hence to use such highly selective devices it has always been necessary to go to the expense of using a multi-stage amplifier.

The above difficulties are all traceable to the fact that in the usual transmitter circuit the entirely separate processes of oscillation-generation, modulation, amplitude-stabilisation, and frequency-stabilisation are all forced into mutual relations by a common retroaction channel. The present paper deals with the obtaining of an enhanced freedom in determining the various properties of a transmitter by the provision of several retroaction channels, each for one process and each working at the optimum level for its particular purpose.

It is shown that such a plan makes it possible to weaken the effect, on amplitude and frequency, of the oscillation-generating channel with its always large voltages, by the use of circuit elements as linear and as independent of frequency as possible. The other retroaction channels then attain, though working at considerably lower power levels, an important influence on amplitude and frequency, so that devices desirable in themselves (such as the highly selective series-resonance crystal already spoken of, or modulators composed of small rectifiers), which could not otherwise be used for simple single-valve circuits, can now be employed. Thus Fig. 7 shows a simple one-valve crystal-controlled circuit giving a comparatively high frequency-constancy. The first retroaction channel leads from the second to the third grid and takes the form of a "kipp" connection (*see* 3491 of 1938). The oscillation-generating channel thus has a low sharpness of tuning and a pronounced amplitude-limiting action. The transmitter is consequently very sensitive to the wattless component of the retroactive voltage brought to the first grid through the oscillating crystal, and very insensitive to its active component. The result is a good frequency-stabilisation by the crystal, combined with an insensitivity, as regards oscillation amplitude, to variations in resonance resistance from one particular crystal to another. Also, since quite small voltages on the first grid are sufficient for frequency-stabilisation, the shunt resistance R_4 can be kept so low that any overloading of the crystal can be avoided definitely. This circuit can also be driven from subharmonics of the crystal frequency: here the crystal is excited by a harmonic of the "kipp" frequency and, continuing its oscillation, provides the synchronising impulse for the next "kipp" period. Thus the oscillating systems described by Kholodenko (1648 of 1942), depending on the interaction of a "kipp" oscillator and a resonator, may be considered to be a special case of multiple retroaction.

While the circuit of Fig. 6 is designed specially for simplicity and economy, Fig. 10 shows another single-valve crystal-controlled circuit designed definitely with the object of high constancy of frequency. The circuit is more complex and a hexode valve replaces the pentode of Fig. 7. The oscillatory energy is taken from the anode circuit through a resonant transformer whose secondary supplies the output terminals A and both retroaction channels. One of these gives both a frequency- and an amplitude-stabilisation by means of a bridge circuit, similar to that of Meacham (263 of 1939) and containing a crystal Q and a thermally controlled resistance H

[Meacham uses a small tungsten-filament lamp] which combine in the differential transformer U_2. This transformer, whose tuned secondary is connected on one side to the first grid, gives good matching between the high valve resistance and the comparatively low resistances of the quartz and the thermally-controlled resistance. The polarity of the bridge is so arranged that, with crystal current predominating, an oscillation-producing voltage appears at the first grid. As the oscillation amplitude rises, the crystal current increases more slowly than the hot-wire current which is opposed to it, thus producing the amplitude-stabilising action desired. In the usual bridge-stabilised oscillators the null-branch of the bridge always has to contain the residual voltage necessary for the maintenance of oscillation ; but by providing a second retroaction channel, for oscillation-production only, this trouble is avoided and almost perfect balancing of the bridge circuit becomes possible. This second channel runs from the secondary of the output transformer (mentioned earlier) through a blocking condenser to the third grid. The various refinements of the complete circuit are discussed at length on pp. 70–74, together with the results obtained.

The final section v deals with the advantages of the use of multiple retroaction in combined emitter–receiver equipments for measuring purposes, capacitive or inductive remote-indication devices, etc : for such purposes the test object, usually connected between the a.c. source and the receiving apparatus, is now connected in a retroaction channel which can take a large value of damping. Such an arrangement is seen in Fig. 16 : the pentode has its oscillation-producing channel from anode to third grid, while the second channel, containing the test object (the bridge circuit B, for example) runs from the oscillating circuit LC_1 through a twin-anode valve EDD11 to the output transformer U_1 and ends at the first grid of the oscillator valve. The push-pull connection of the twin anodes, which are supplied directly from the mains transformer U_2, results in an automatic periodic reversal of polarity in the second retroaction channel ; an alternate damping and stimulating action on the oscillator ; consequently, an alternately greater and smaller amplitude of oscillation ; and therefore a greater and smaller modulation of the EDD11 valve, in each whole period of the mains supply. Since this valve works on the lower bend of its characteristic, the d.c. anode current of that anode which is effective at the time of the larger oscillations will predominate, so that the balance of a d.c. bridge (P_2, R_5, R_6), connected to the ends of the two anode half-windings of the mains transformer, will be disturbed : the centre-zero milliammeter in the diagonal will be deflected according to the magnitude of the alternating voltage appearing beyond the test object B, and the sense of the deflection will depend on whether a phase reversal has occurred in the path from the output transformer U_1 to the first grid of the oscillator valve.

The advantages and possible applications of such an arrangement are discussed on p. 75 (one advantage is the insensitivity to fluctuations in working conditions, derived from the differential nature of the action) and in particular a special method of use in which the retroactive coupling of the oscillator is adjusted (by the bias on the third grid, regulated by the cathode resistance P_1) so that when the bridge forming the " test object " B is nearly balanced the oscillations are stopped : thus the indicating meter remains at zero so long as the bridge unbalance is kept within certain limits, but gives a large deflection when these limits are exceeded, so that the arrangement is useful for the rapid checking of large numbers of similar components. As a condenser-measuring equipment the circuit is very suitable for small capacitances, such as those of valves. Fig. 17 shows that the sensitivity is sufficient to allow capacitances of a few tenths of a picofarad to be tested within about 1%.

69. QUARTZ-CRYSTAL CUTS [Basic Cuts & Recent Modifications].—Elbl. (*See* 165.)

70. ON A CERTAIN TYPE OF PARASITIC OSCILLATIONS.—P. V. Shabanov. (*Izvestiya Elektroprom. Slab. Toka*, No. 11, 1940, pp. 13–20.)

Continuing the work dealt with in 2359 of 1943, a theoretical analysis is presented of parasitic oscillations of the " circular " type which may occur when two valves are so connected that they can oscillate parasitically in series (*see* Fig. 1). Oscillations of this type may appear not only in short-wave transmitters but also in long-wave equipment where, for example, several valves are operated in parallel. Conditions necessary for the appearance of these oscillations are derived and methods are indicated for determining their frequency. Measures for their suppression are discussed and a number of practical suggestions are made.

71. KEYED TRANSMITTERS WITH SHORTENED SIGNAL-IMPULSE RISE, GIVING INCREASED TELEGRAPHIC SPEEDS [Use of Valves with Disproportionately High Emission, giving Considerably Larger Current on " Make " than in the Stationary State].—W. Kummerer. (*Hochf:tech. u. Elek:akus.*, April 1943, Vol. 61, No. 4, p. 124.) A Telefunken patent, D.R.P.726 089.

72. METHOD FOR THE TRANSMISSION OF INFORMATION WITH THE USE OF A NARROW FREQUENCY-BAND.—Fischer. (*See* 244.)

RECEPTION

73. THE SYNCHRONOUS AMPLIFICATION OF FREQUENCY-MODULATED SIGNALS.—B. Sh. Kissel'gof & A. D. Knyazev. (*Izvestiya Elektroprom. Slab. Toka*, No. 10, 1940, pp. 16–30.)

In receiving f.m. signals, these are amplified at high and intermediate frequencies and after passing through an amplitude-limiter are applied to the frequency detector. In this paper a circuit is proposed for amplification and amplitude-limitation based on the use of an oscillator operating under pulling-in conditions. If the external e.m.f. applied to the oscillator lies within the pulling-in range, the frequency generated by the oscillator (called the synchronous oscillator) will be equal to that of the external e.m.f. Thus in the case of f.m. signals the oscillator will also be frequency modulated. Since the voltage generated by the oscillator greatly exceeds the applied voltage, the oscillator can be regarded as a synchronous amplifier. To make full use of the oscillator for the reception of f.m. signals it is important to be able to regulate the width of the pulling-in range, the latter being dependent on the amplitude of the local oscillations, so that for a given external voltage the smaller the amplitude the wider the range. It should also be possible to limit the amplitude of the local oscillations in order to reduce the effects of interference. Both these objects can be achieved by the use of a diode, with a negative bias on the anode, connected in parallel with the tuned anode circuit of the oscillator. The diode operates as a shunt, the value of which depends on the instantaneous voltage developed across the tuned circuit, and can also be regulated by adjusting the anode bias.

Several practical circuits are proposed (Fig. 1) and their operation discussed under the following headings : the equation of the synchronous oscillator, the amplitude-limiting characteristic, amplification factor of the syn-

chronous amplifier, and distortion. A short report is also given on experiments which have confirmed the theoretical deductions. It stated in conclusion that the circuit proposed fulfils its functions satisfactorily.

74. The Development of Frequency Modulation [Survey of Literature].—A. D. Knyazev. (*Izvestiya Elektroprom. Slab. Toka*, No. 10, 1940, pp. 39–43.) Including the following Russian works: Siforov—The Effect of Interference during Reception (4030 of 1936); Pestryakov—The Effect of Aperiodic Interference in F.M. Receivers (3535 of 1938 and 114 of 1939) *and* The Detection of F. M. Oscillations (*Elektrosvyaz*, No. 2, 1938); and Levin & Gadiev—An Amplitude Limiter in F.M. Circuits (*Elektrosvyaz*, No. 5, 1939: and *see* 1940 of 1942).

75. Frequency-Modulated Broadcast picked up and reproduced by Public Address System [by "Some Hard-to-Explain Circuit Peculiarity"]. —(*Electronics*, July 1943, Vol. 16, No. 7, p. 228.)

76. Ultra-Short Electromagnetic Waves: VI—Reception [Propagation, and the Use of Directive Aerials (and the Received Power Equation $w_r = 16 \cdot 2\pi^2 w S^2 (h/r\lambda)^4$): Signal/Noise Ratio, and the Matched Condition (and the Possible Improvement over the Matched Condition: quite Small, especially at the Higher Frequencies: the "Excess-Noise Ratio" & Its Usefulness), the Band-Width Factor, & Ignition Interference: etc.].—B. Trevor. (*Elec. Engineering*, Sept. 1943, Vol. 62, No. 9, pp. 405–409.) For previous parts of this series *see* 1, above, & 102, below, and 2632/3 & 2998 of 1943. The series is now complete, and will be issued as a pamphlet (*see* p. 412).

77. Very-High-Frequency Receiver Oscillator Design [Speculations on the Future, but with Present Applications: "Secular" Stability: Avoidance of Constructional Material subject to Appreciable Cold-Flow or Change of Volume with Age: Circuit Resistances (Sliding Contact to Condenser Rotor, etc.): "Q" of Tuned Circuits: Valve Changes: Voltage Stability ("No Direct Relationship with 'Q'-Value" as generally assumed): Striking Voltage: the Optimum L/C Ratio at These Frequencies].—S. Y. White. (*Electronics*, July 1943, Vol. 16, No. 7, pp. 96–97 and 206, 208.)

78. On the Interaction between a Diode and a High-Frequency Voltage Source in the Rectification of Modulated High Frequency.—H. Roder. (*Telefunken-Röhre*, No. 26, 1942, p. 65 onwards.) A thirty-page paper.

79. Tubes drive Relay in Telegraph-Repeater Circuit [Circuit for making Weak Signals operate a Polarised Relay].—A. F. Connery. (*Electronics*, June 1943, Vol. 16, No. 6, pp. 226..230.)

80. Receiving Installation comprising Several Aerials and Receivers [for Alternative Reception by Diversity and Musa Methods].—G. Vogt. (*Hochf:tech. u. Elek:akus.*, April 1943, Vol. 61, No. 4, p. 124.) A Telefunken patent, D.R.P.726 090.

81. Some Effects of Geologic Structure on Radio Reception.—B. F. Howell, Jr. (*Geophysics*, April 1943, Vol. 8, No. 2, pp. 165–176.)

"Less well known [than the common shadow zones behind hills, buildings, in deep road cuts, tunnels, etc.] are the effects of overhead wires, with which are associated 'weak areas' or 'dead spots'. . . . Besides these obvious cases of shielding, there appear to be other less well understood causes of weak spots of radio reception. It has been suggested that certain geologic structures, notably contacts between rocks of different composition, especially fault contacts, might have some influence on the r.f. fields in their neighbourhood. Relatively little work has been done on this problem; and what has been done has not, in most cases, been published. The result is that no clear explanation of the relationship between geologic structures and radio weak spots has been made known. . . . The first direct test of the effects of faults and contacts was reported by Ernst Cloos (ref. "1"). . . . Cloos's findings have been corroborated in other regions by unpublished experiments. Mr. W. M. Barrett has developed a method similar to that described below whereby he claims to be able to locate faults by their effect on the field produced by a portable broadcast station set up nearby" [U.S. Patent].

The problem undertaken in the present work was to examine certain geologic structures to ascertain if there were any irregularities in the radio field (produced by regular broadcasting transmissions) near these structures; and also to examine any known available "weak spots" which appeared to be connected with geologic structure, to determine exactly what the effect of the structure was (the primary object being to develop a simple and inexpensive method of locating and tracing faults and contacts). Heiland, in his book (*see* 2946 of 1941) attributed "weak spots" to distortions of the equipotential lines near the contacts of good and poor conductors: Barrett considers the observed field distortions over faults to be due to secondary fields, while Mingins (833 of 1938), studying the effect of the ground on sky-wave reception, has shown how the direction of the field would be affected by an underground conducting body. The present writer suggests that fault planes have higher conductivities than the surrounding rocks, because of the presence of certain minerals or because they contain more water than the adjacent rocks: where these conditions are specially in force, secondary fields would be produced strong enough to alter the direction of the resultant total field: "this would explain why disturbed areas occur only at a few places along faults." He considers that interference by reflected and refracted rays, as well as secondary fields, are probably involved in the formation of "weak spots," and "only further study will show the relative importance of each."

His surveys lead to the following conclusions, among others: that in rugged and densely inhabited areas the variations due to non-geologic causes are so great as to hide completely any variations due to geologic causes: that weak fields seem to be more strongly affected than strong ones: that the study of directional effects is at least as promising as that of intensity variations: and that further researches are badly needed, preferably with more sensitive apparatus and a controlled local transmitter to replace the standard broadcast signals. Finally, "more detailed work is needed on the theory of the reflection and refraction of radio waves at surfaces in or on the ground, including the calculation of expectable anomalies."

82. Arrangement to Eliminate the Side-Band Interference by Stations on Adjacent Frequencies, in Broadcast Receivers.—G. Holst & B. D. H. Tellegen. (*Hochf:tech. u. Elek:akus.*, April 1943, Vol. 61, No. 4, p. 125.)

A Philips Company patent, D.R.P.727 234. "By a comparison between the interfering amplitudes in the related sidebands of the carrier-frequency to be received, a control quantity is derived which automatically reduces the influence of the interference-suffering sideband on the reception."

D

83. Elimination of Short-Period Interference [L.F. Interference Voltages in Aerial are Rectified and used to Reduce the Transmission Equivalent].—K. Lämmchen & O. Henle. (*Hochf:tech. u. Elek: akus.*, April 1943, Vol. 61, No. 4, p. 125.) A "Blaupunkt" patent, D.R.P.726 343: no details are given.

84. Circuits for suppressing Pulse Interference in Radio Receivers.—V. E. Magdesiev & A. A. Fersman. (*Izvestiya Elektroprom. Slab. Toka*, No. 10, 1940, pp. 44–50.)

There are three types of circuits for suppressing interference from industrial sources, which usually takes the form of short pulses of great intensity: (1) circuits reducing the interference amplitude to the level of the maximum signal amplitude; (2) circuits reducing to zero the voltages of both the signal and interference at the moment when interference takes place, and (3) circuits reducing the interference voltage to the level which the signal had when interference appeared. Circuits suitable for each type of operation, including those developed in Russia, are shown and discussed. The third type is considered to be the most satisfactory, but all three types operate only if the interference voltage exceeds that of the signal during 100% modulation. Experimental curves are plotted (Figs. 8 & 9) showing a probable distribution of amplitudes per second corresponding to interference from various industrial sources. It is clear from these curves that the circuits discussed may not be effective under certain conditions. Accordingly, a circuit (Fig. 10) is proposed in which the sensitivity is automatically regulated according to the depth of the signal modulation. In conclusion, circuits with automatic adjustment of sensitivity depending on the carrier-wave voltage are briefly discussed.

85. On the Interference with Radio Reception caused by High-Frequency Welding, and Methods for Its Suppression.—S. A. Lyutov & Kh. I. Lev. (*Izvestiya Elektroprom. Slab. Toka*, No. 10, 1940, pp. 55–61.)

Spark oscillators used for arc welding can cause severe interference with radio reception. Tests were carried out to measure the interference produced by an oscillator of Russian manufacture, and various methods were suggested for its suppression. Each method was thoroughly tested, and it is concluded that the interference can be practically eliminated if the following measures are adopted: (a) the feeding of the oscillator through a screened transformer (this ensures that the oscillator is switched off during the periods of idleness and also reduces interference during the welding periods), (b) protection, by filters, of the supply mains feeding the welding transformer, (c) use of an h.f. choke at the output of the oscillator to suppress frequencies above that to which the oscillator is tuned, and (d) screening of the leads and of certain components of the circuit.

86. Suppression of Radio Interference from Electric Motors [D.C. Motor as Source of Quasi-Continuous R.F. Spectrum, with Maximum near Resonance-Frequency of Armature-Section: Possibility of Interference-Reduction in a Particular Band by Displacement of This Point (Howe, 3666 of 1937): Experiments with Fan Rotor carrying .005 μF Condensers across Each Pair of Commutator Segments: Other Tests with Condenser across Brushes].—S. R. Khastgir & S. M. Sen. (*Current Science* [Bangalore], May 1943, Vol. 12, No. 5, pp. 146–147.)

87. Radio-Noise Elimination in All-Metal Aircraft.—F. Foulon. (*Elec. Engineering*, Aug. 1943, Vol. 62, No. 8, p. 374: summary only.)

88. Radio-Noise Filters applied to Aircraft [including Sections on Faulty Couplings in Filters (interfering with Predicted Performance), Measurements under Operating Conditions, & Laboratory Circuit for Filter-Performance Tests].—C. W. Frick & S. W. Zimmerman. (*Elec. Engineering*, Sept. 1943, Vol. 62, No. 9, Transactions pp. 590–595.) Summaries were referred to in 2991 & 3366 of 1943.

89. Interference with Reception in Aircraft, due to Corona from Static Charges.—Little. (*See* 22.)

90. The Two Most Important "Tone-Diaphragm" Circuits [Simple Low-Pass *RC* Filters for A.F. Amplifiers, to reduce Adjacent-Channel Interference, General Noise Level, & Needle Scratch].—E. de Gruyter. (*Bull. Assoc. Suisse des Élec.*, 25th Aug. 1943, Vol. 34, No. 17, pp. 506–510: in German.)

Actually, needle scratch is dealt with better by a real filter, since its spectrum is a comparatively narrow one. Author's summary:—"In preparation for a later article devoted to the calculation of amplifiers with the help of the complex coefficient of amplification, the author studies the behaviour of two 'tone-diaphragm' circuits used for limiting the frequency band in a.f. amplifiers. The complex impedance is already introduced in the scheme of connection and calculated, relatively, as a vector of the complex plane of representation. Since, for such 'tone-diaphragms,' the phase displacement between voltage and current is of no interest, only the value of the impedance is derived from the formulae and represented by curve families of general application. On the other hand, for the complex coefficient of amplification the phase also is of importance, since it determines the phase displacement between the input and output voltages of an amplifier."

The two simple circuits considered are the parallel low-pass connection (Fig. 1, equivalent circuit Fig. 2) and the anode-blocking connection (Fig. 5, equivalent circuit Fig. 6). The two arrangements are first considered purely from the electrical point of view, but the final comparison (Figs. 9 & 10) takes the characteristics of the ear into account. The whole treatment follows the lines of the writer's earlier paper on the "reciprocal representation" of circuit behaviour (1840 of 1939: *see* also 1629/30 of 1942).

91. The Use of Negative Feedback in the Audio-Frequency Amplifiers of Broadcast Receivers.—V. A. Govyadinov. (*Izvestiya Elektroprom. Slab. Toka*, No. 10, 1940, pp. 30–38.)

It is shown in an introduction that voltage feedback should be used and that it should be taken off the secondary of the output transformer and applied to the input of the penultimate stage. The subject is then discussed under the following headings: correction of frequency characteristics, reduction of non-linear distortion, increase in attenuation of the amplifier output circuit and reduction of background noise due to negative feedback.

In conclusion it is stated that the use of negative feedback cannot be recommended for cheap mass-produced receivers, but that definite advantages can be gained in high-quality models. The discussion applies only to stages employing valves with more than three electrodes, since there is no advantage in using feedback with triodes.

92. New Bass-Boosting Circuit [Simplified Circuit resulting from Correspondence on the Two-Valve Screen-Grid Injection Circuit, 3819 of 1940].—L. M. Barcus. (*Electronics*, June 1943, Vol. 16, No. 6, pp. 216..222.)

93. Musical Taste [True Jazz Fans do *Not* prefer "Topless" Reproduction: Causes of Prevalent Taste for "Mellow" Tone].—P. B. Fellgett. (*Wireless World*, Nov. 1943, Vol. 49, No. 11, p. 345.)

94. Audio-Perspective System for Home Radio Receivers [System with Amplifiers, Filters, Expanders, & Three Loudspeakers, to replace A. F. Section of Ordinary High-Quality Receiver].—I. Volpe. (*Electronics*, Aug. 1943, Vol. 16, No. 8, p. 156.)

95. New Development in Radio Receiving Technique. V. A. Govyadinov. (*Izvestiya Electroprom. Slab. Toka*, No. 10, 1940, pp. 50–55.)

A survey is made of modern tendencies in the design of broadcasting receivers both in Russia and abroad. Superheterodynes still predominate. A table is prepared showing the advantages and disadvantages of various types of push-button tuning. A few remarks are made on the remote control of receivers, a.c./d.c. operation, and the construction of components. A table is included giving the operating data of the type D (1.4 v filament voltage) German valves. The use of negative feedback and of anti-interference circuits is considered, as well as the prospects of frequency modulation. The loudspeakers, the frame aerials, and the cabinets are also discussed. In conclusion, special requirements affecting radio receivers in Russia are set out. *See* also 96, below.

96. New Developments in Broadcast Receivers.—V. A. Govyadinov. (*Izvestiya Elektroprom. Slab. Toka*, No. 11, 1940, pp. 30–38.)

A survey of modern trends in Russia in the design of domestic radio receivers. It is considered that push-button tuning is fully justified in mass-produced sets; inductance-changing is preferred to the rotation of a gang condenser by electrical or mechanical means. A group of related receivers of Russian manufacture are then described. These are 5-valve (including rectifier) superheterodynes having the general circuit of Fig. 7. Push-button tuning is provided for 8 stations, operating on dust cores in the aerial and beating-oscillator coils. The difficulty of ganging has been overcome by splitting the beating-oscillator inductance between two coils in series, with a separate adjustment on the second coil.

Whether high-quality receivers for local stations only shall be put into production has not yet been decided, but as no great extension of wire rediffusion is expected in Russia, such a receiver has been developed. This is again a 5-valve (including rectifier) superheterodyne (Fig. 8) using negative feedback in the l.f. amplifier. There are three controls: the first gives a choice of 3 stations or gramophone, the second is the volume control, and the third a 3-position tune control. The present tuning circuits are preadjusted by dust cores.

97. "Utility" Broadcast Receivers: What would be the Most Suitable Circuit Arrangement? ["Codon" rejects the Straight Two-Valve Set (Volksempfänger) as Inadequate during Air-Raids, and advocates Three-Valve (+ Rect.) A.C./D.C. Superheterodyne].—(*Wireless World*, Nov. 1943, Vol. 49, No. 11, pp. 338–339.) *Wireless World* Brains Trust.

98. 1942 Radio Receiver Sales by Factories [with Figures for Different Types, including Television, Remote-Control Devices, etc.].—(*Electronics*, May 1943, Vol. 16, No. 5, p. 186.)

99. Correction to "The Development and Present Position of the Broadcast Receiver Industry of the World" [3370 of 1943].—W. F. Ewald. (*E.T.Z.*, 17th June 1943, Vol. 64, No. 23/24, p. 338.) On p. 273, l-h column, the fifth line from the bottom should read "about ¼ million receivers per year".

100. The Application of the Vacuum-Tube Voltmeter to Radio Servicing [and the Design of a Suitably Simple and Reliable Valve-Voltmeter for Service-Men].—R. Lackey. (*Proc. Inst. Rad. Eng. Australia*, April 1943, Vol. 5, No. 1, pp. 9–15.)

101. Low-Capacitance A.C. Power Supplies.—G. Mountjoy & C. W. Finnigan. (*Bulletin, Inst. Rad. Eng. Australia*, March 1943, pp. 2–4.) *See* 1246 of 1943.

AERIALS AND AERIAL SYSTEMS

102. Ultra-Short Electromagnetic Waves: V—Radiation [Part 2].—A. Alford. (*Elec. Engineering*, Aug. 1943, Vol. 62, No. 8, pp. 338–344.)

The first part of this paper (2998 of 1943) described the method used to calculate the radiation fields of radiators with a known current distribution: the present part describes a second method which is useful when the field near the radiator is known. "This method is relatively new and is still somewhat in a state of flux. This method is replacing the Kirchhoff–Huygens procedure which has been used in early calculations of radiation from wave guides, electromagnetic horns, and so forth . . ." In Method 2 one is dealing with currents and charges, which are familiar, whereas with the Kirchhoff–Huygens procedure one has to use a function whose physical meaning is not clear: a considerable number of erroneous results have been obtained in problems involving apertures, because of the difficulty in finding the proper function which must be added to take care of conditions along the boundary of an aperture. The new method is based on a combination of the method developed in the first part and the equivalence principle.

103. Coaxial Antenna [in Frequency Range 30–200 Mc/s: Type 899 Factory-Tuned "Whip & Skirt" Radiator].—V. J. Andrew Company. (*Electronics*, July 1943, Vol. 16, No. 7, p. 234.)

104. Design Data for "Ground Plane" Antennas [Brown & Epstein, 3836 of 1940: Ultra-High-Frequency Aerial for Low-Angle Radiation: Basic Formulae for Design: Example, with 78-Ohm Termination at 33.78 Mc/s: Calculation of Characteristic Impedance: Comparison of Resistances calculated by Brown & Epstein (*loc. cit.*), Morrison & Smith (3681 of 1937: Shunt-Excited Antenna), and King & Blake (423 of 1943)].—H. W. Hasenbeck. (*Electronics*, Aug. 1943, Vol. 16, No. 8, pp. 98–101.)

105. The Calculation of Loop Aerials [as used in Radio Beacons].—Plemyannikov & Ermolov. (*See* 129.)

106. The Stabilisation of the Phases and Amplitudes of the Currents in Aerials [in Radio Beacon Systems].—L. E. Shtillerman & G. A. Soskin. (*See* 130.)

107. The Radiation Resistance of a Line carrying Standing and Travelling Waves.—A. L. Drabkin. (*E.T.Z.*, 25th Feb. 1943, Vol. 64, No. 7/8, pp. 109–110.) Summary of the paper dealt with in 440 of 1942: the three final equations and a

diagram are reproduced. For a longer paper *see* 2367 of 1942.

108. Modern Insulation Methods for Transmitting Aerials.—A. Strauss. (*Zeitschr. f. Fernmeldetech.*, Vol. 23, 1942, p. 161 onwards.)

109. Modified Protective Gap for Transmitting Antennas [Defect of Usual Method of removing Carrier during Static Discharge (for Protection of Meters, etc.): Modified Arrangement in which Relay is Not affected by Induced Currents from Tower Lighting Wires].—A. Leeman. (*Electronics*, May 1943, Vol. 16, No. 5, pp. 128 and 130.)

VALVES AND THERMIONICS

110. Noise Measurements in Vacuum Tubes [Rapid & Simple Measuring Set: Alternative Set (G. L. Pearson) when Different Types of Valve are to be Tested].—J. J. DeBuske. (*Bell Lab. Record*, Aug. 1943, Vol. 21, No. 12, pp. 456–458.)

111. "Die Sekundär-Elektronen-Emission fester Körper" [of Solid Bodies: Book Review].—H. Bruining. (*E.T.Z.*, 11th Feb. 1943, Vol. 64, No. 5/6, p. 90.) From the Philips laboratories: it forms Vol. 5 of the Meissner–Holst series "Technische Physik in Einzeldarstellungen". The reviewer suggests a few recent researches which might be included in a second edition.

112. Sixty Years of Electronics, 1883–1943, *and* Electron Tubes for Industry and Communication [Graphic Portrayals].—(*Electronics*, July 1943, Vol. 16, No. 7, between pp. 112 & 113.)

113. New Army-Navy Preferred List of Vacuum Tubes.—(*Electronics*, May 1943, Vol. 16, No. 5, p. 182.)

114. A Vacuum Furnace [for the Heat Treatment of Materials or Parts under Vacuum Conditions: Disadvantages of Eddy-Current & External-Heat Methods: a Satisfactory Furnace with Internal Heater].—W. Ehrenberg & F. Ansbacher. (*Journ. of Scient. Instr.*, Oct. 1943, Vol. 20, No. 10, pp. 164–165.) From the E.M.I. Laboratories.

115. Fluorescent Inspection of Tungsten [for Minute Longitudinal Cracks].—S. A. Kulin. (*Electronics*, July 1943, Vol. 16, No. 7, pp. 95 and 160, 162.) For an eddy-current method *see* 3411 of 1943.

116. Training Girls to make Tubes [General Electric Company's System].—L. A. Yoder. (*Electronics*, Aug. 1943, Vol. 16, No. 8, pp. 106–107 and 228, 230.)

DIRECTIONAL WIRELESS

117. Arrangement for determining the Distance of Reflecting Surfaces, especially for measuring the Flying Height of Aircraft.—E. Pätzold & G. Ernst. (*Hochf:tech. u. Elek:akus.*, April 1943, Vol. 61, No. 4, p. 126.)

A Siemens & Halske patent, D.R.P.726 461. "In the known method by which the transmitted frequency is continuously varied, and the difference-frequency obtained in the receiver by superposition of the direct and reflected rays is used as measure of the distance, the most constant output voltage possible is obtained by making amplification in the receiver dependent on the difference frequency, and thus on the distance. This is done, for example, by using a pentode amplifier in combination with a frequency-dependent anode resistance (choke)".

118. Radar Stories are released by U.S. and Great Britain [with Conclusions drawn from the Two Accounts].—(*Electronics*, June 1943, Vol. 16, No. 6, pp. 274..282.)

119. The Second Navy Press Release on Radar.—(*Electronics*, July 1943, Vol. 16, No. 7, pp. 212..219.)

120. Arrangement for Reducing the Horizontal Component in the Radiation Field of a Guide-Beam Beacon.—K. Fränz. (*Hochf:tech. u. Elek: akus.*, April 1943, Vol. 61, No. 4, p. 126, Fig. 6.)

A Telefunken patent, D.R.P.727 160. In a beam transmitter of the type consisting of a single radiator between two alternately keyed reflectors, the aerial system is raised above the ground and just above a metal surface, and the two reflectors are inclined with respect to the radiator, in a plane perpendicular to the direction of the beam.

121. Arrangement for Producing a Guide-Beam [Two Dipole Aerials fed from Common Source, Simultaneously but with Periodically Varying Phase: Special Arrangements for Elimination of Load-Fluctuations on the Transmitter and Prevention of Key-Clicks].—H. E. Paul. (*Hochf:tech. u. Elek: akus.*, April 1943, Vol. 61, No. 4, p. 126, Fig. 7.) A Telefunken patent, D.R.P.727 161, applied for 9/2/1940.

122. Transmitting Arrangement for the Production of a Guide Beam formed by the Line of Section of Two Radiation-Diagrams, for Use with a Super-Regenerative Receiver.—W. Runge. (*Hochf:tech. u. Elek:akus.*, April 1943, Vol. 61, No. 4, p. 126, Fig. 9.)

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124. Pulse Direction-Finding Receiver.—P. Nicolas. (*Hochf:tech. u. Elek:akus.*, April 1943, Vol. 61, No. 4, p. 126, Fig. 8.)

An S.F.R. patent, D.R.P.726 216. In a system in which the length of the transmitted pulse exceeds the interval between the direct signal and the echo, "the pulse image shown on a cathode-ray tube is so positioned that the strongest extinction occurs at the beginning of the oscillogram. By the commutation, during the interval between two pulses, of a directional and a non-directional aerial, the sum and difference of the aerial voltages are applied alternately to that deflecting system which is not in use for the time-based eflection, so that the screen-pattern shown in Fig. 8 is obtained. When the directional

aerial is so oriented that the beginnings of the two curves coincide with the dotted centre-line, the arrival angle of the transmitting station is found."

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126. METHOD OF INDICATION FOR THE FIELD-STRENGTH COMPARISON OF TWO RADIATION-DIAGRAMS [for Equi-Signal Beacons: Use of an Additional Distinguishing Characteristic (Change of Carrier-Frequency, or Auxiliary Modulation) and a Commutating Device at Receiver].—E. Kramar. (*Hochf:tech. u. Elek:akus.*, April 1943, Vol. 61, No. 4, p. 126.) A Lorenz patent, D.R.P. 726 877.

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128. BUOY RADIOBEACONS FOR INSHORE NAVIGATION.—(*Electronics*, July 1943, Vol. 16, No. 7, pp. 88–91.)

129. THE CALCULATION OF LOOP AERIALS.—A. N. Plemyannikov & A. K. Ermolov. (*Izvestiya Elektroprom. Slab. Toka*, No. 11, 1940, pp. 20–23.)

The theory of lines with distributed constants is applied to the case of a single-turn loop aerial such as is used for radio beacons. The aerial can be regarded as a complex line consisting of several non-uniform sections and short-circuited at the end. Each half of the aerial up to the middle point then represents one of the conductors of the line. Methods are indicated for a complete design of the aerial, including formulae 3 & 5 for calculating the reactance of the tuning elements (formula 5 refers to the case when the loading condenser is mounted at the top of the aerial to reduce night error).

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131. POST-WAR CIVILIAN-AVIATION RADIO PROSPECTS.—R. E. Ricketts. (*Electronics*, Aug. 1943, Vol. 16, No. 8, pp. 86–89 and 276.)

PHOTOTELEGRAPHY AND TELEVISION

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133. INTERNATIONAL TELECOMMUNICATIONS: POST-WAR RADIO DEVELOPMENTS [including the Future of Television: Inaugural Address, President I.E.E.].—A. S. Angwin. (*Wireless World*, Nov. 1943, Vol. 49, No. 11, p. 339: summary only.)

134. THE MULTIPLE SCANNING OF FILMS [where the Image-Change & Film-Change Frequencies are Different].—R. Möller. (*Fernseh-Hausmitt.*, Oct. 1942, Vol. 2, No. 5, p. 129 onwards.)

With intermittent film motion only one system is possible, that in which the film is illuminated at its moments of repose and a storage-type of picture-analyser is employed: with a supericonoscope, usable results are thus obtained. But for increased life of the films and for simpler mechanism it is desirable to use continuous motion of the film, and for the necessary shift-correction two plans are fundamentally possible: (i) continuous adjustment, either by optical methods such as moving mirrors, etc. (as in the Mechau projector) or by electron-optical methods (supericonoscope); the latter plan demands almost impossible electrical qualities on the part of the switching organ: and (ii) abrupt adjustment, either by way of the image-change pulse amplitude (as by a development of the spiral-aperture disc: the use of electron-optical scanning devices would probably fail because of the accuracy required) or by optical displacement, for example with the help of a prism. These various schemes are discussed from the viewpoint of their practical possibilities.

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136. LIGHT-RAY SCANNER WITH CATHODE-RAY TUBE FOR CARRIER-FREQUENCY AND LOW-FREQUENCY SCANNING.—K. Brückersteinkuhl. (*Fernseh-Hausmitt.*, Oct. 1942, Vol. 2, No. 5, p. 143 onwards.)

For 441-line television the use of light-spot scanning with a cathode-ray tube demands a fluorescent screen with an afterglow time of less than 2.5×10^{-7} second, and since this is not obtainable in practice it becomes necessary to circumvent the difficulty by some way of eliminating the effect of the after-glow. One way of doing this is to modulate the beam, and with it the scanning spot, with a carrier frequency higher than the picture frequency. A second way is to use a compensating process in which an amplifier-stage on the far side of the photocell provides an auxiliary voltage which opposes the voltage due to the after-glow. In the present paper the writer examines the pros and cons of these two methods, and concludes that the first is a completely successful but somewhat complex solution of the problem, whereas the second is a fundamentally incomplete solution which is easier to carry out. Some practical results are described.

137. A DELAY ELEMENT FOR THE UNIFORM DELAYING OF A WIDE FREQUENCY-BAND [Television Signals: Winding, between Inner & Outer Earthed Copper Sleeves, around Magnetic Core: Distortion due

diagram are reproduced. For a longer paper *see* 2367 of 1942.

108. MODERN INSULATION METHODS FOR TRANSMITTING AERIALS.—A. Strauss. (*Zeitschr. f. Fernmeldetech.*, Vol. 23, 1942, p. 161 onwards.)

109. MODIFIED PROTECTIVE GAP FOR TRANSMITTING ANTENNAS [Defect of Usual Method of removing Carrier during Static Discharge (for Protection of Meters, etc.): Modified Arrangement in which Relay is Not affected by Induced Currents from Tower Lighting Wires].—A. Leeman. (*Electronics*, May 1943, Vol. 16, No. 5, pp. 128 and 130.)

VALVES AND THERMIONICS

110. NOISE MEASUREMENTS IN VACUUM TUBES [Rapid & Simple Measuring Set: Alternative Set (G. L. Pearson) when Different Types of Valve are to be Tested].—J. J. DeBuske. (*Bell Lab. Record*, Aug. 1943, Vol. 21, No. 12, pp. 456–458.)

111. "DIE SEKUNDÄR-ELEKTRONEN-EMISSION FESTER KÖRPER" [of Solid Bodies: Book Review].—H. Bruining. (*E.T.Z.*, 11th Feb. 1943, Vol. 64, No. 5/6, p. 90.) From the Philips laboratories: it forms Vol. 5 of the Meissner–Holst series "Technische Physik in Einzeldarstellungen". The reviewer suggests a few recent researches which might be included in a second edition.

112. SIXTY YEARS OF ELECTRONICS, 1883–1943, *and* ELECTRON TUBES FOR INDUSTRY AND COMMUNICATION [Graphic Portrayals].—(*Electronics*, July 1943, Vol. 16, No. 7, between pp. 112 & 113.)

113. NEW ARMY-NAVY PREFERRED LIST OF VACUUM TUBES.—(*Electronics*, May 1943, Vol. 16, No. 5, p. 182.)

114. A VACUUM FURNACE [for the Heat Treatment of Materials or Parts under Vacuum Conditions: Disadvantages of Eddy-Current & External-Heat Methods: a Satisfactory Furnace with Internal Heater].—W. Ehrenberg & F. Ansbacher. (*Journ. of Scient. Instr.*, Oct. 1943, Vol. 20, No. 10, pp. 164–165.) From the E.M.I. Laboratories.

115. FLUORESCENT INSPECTION OF TUNGSTEN [for Minute Longitudinal Cracks].—S. A. Kulin. (*Electronics*, July 1943, Vol. 16, No. 7, pp. 95 and 160, 162.) For an eddy-current method *see* 3411 of 1943.

116. TRAINING GIRLS TO MAKE TUBES [General Electric Company's System].—L. A. Yoder. (*Electronics*, Aug. 1943, Vol. 16, No. 8, pp. 106–107 and 228, 230.)

DIRECTIONAL WIRELESS

117. ARRANGEMENT FOR DETERMINING THE DISTANCE OF REFLECTING SURFACES, ESPECIALLY FOR MEASURING THE FLYING HEIGHT OF AIRCRAFT.—E. Pätzold & G. Ernst. (*Hochf:tech. u. Elek:akus.*, April 1943, Vol. 61, No. 4, p. 126.)

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138. Static Method for the Distribution of Electric Pulses between Several Channels: Applications to Television.—P. Toulon. (*Bull. Soc. Franc. des Élec.*, Series 6, Vol. 2, 1942, p. 64 onwards.)

139. Iron-Core Components in Pulse Amplifiers [" a Discussion of the Rate of Voltage Change in the ' Leading Edge,' ' Flat Top,' and ' Trailing Edge ' Portions of Square-Wave or Flat-Top Pulses when impressed on Iron-Core Reactors "]. —R. Lee. (*Electronics*, Aug. 1943, Vol. 16, No. 8, pp. 115–117 and 262..268.)

140. Properties of Low-Reflection Films produced by the Action of Hydrofluoric-Acid Vapour [Further Development of Work dealt with in 2415 of 1942].—F. H. Nicoll & F. E. Williams. (*Journ. Opt. Soc. Am.*, Aug. 1943, Vol. 33, No. 8, pp. 434–435.) " More durable than the best evaporated films."

MEASUREMENTS AND STANDARDS

141. The Radio-Frequency Capacitometer [Self-Contained Cathode-Ray-Tube Instrument for the Precise R.F. Measurement of Capacitance & Inductance (0–1000 $\mu\mu$F, 0–1000 μH, within $\pm$0.1 $\mu\mu$F and $\pm$ 0.1 μH at Lower Values, $\pm$0.1% at Higher): Substitution Method so arranged that Results may be read Directly: the Easily Recognisable 3-to-2 Pattern as Indicator]. — F. J. Moles. (*Gen. Elec. Review*, Aug. 1943, Vol. 46, No. 8, pp. 457–459.)

142. An Electronic Voltmeter for High Voltages [Simple Cathode-Ray Tube (without Deflecting Plates or Special Focusing: Shadow of " Obstacle " situated at Cross-Over is used as Pointer) for Direct Measurement up to 50 kV].—W. Ehrenberg & H. Hirsch. (*Journ. of Scient. Instr.*, Oct. 1943, Vol. 20, No. 10, pp. 161–163.) From the E.M.I. Laboratories.

143. Voltage Measurement at High Frequencies [Short Survey: Moving-Coil Voltmeter & Rectifier (and the Types of Rectification—" A " & " C "—employed): Electrostatic & Thermoelectric Voltmeters: Range Extension by Voltage-Divider & Amplifier: Errors in Voltage Measurement].—H. F. Grave & O. Zinke. (*E.T.Z.*, 11th Feb. 1943, Vol. 64, No. 5/6, pp. 74–76.) About the latest paper referred to is that of Böcker on electrostatic meters (162 of 1941).

144. The Application of the Vacuum-Tube Voltmeter to Radio Servicing [and the Design of a Suitably Simple & Reliable Valve-Voltmeter for Service-Men].—R. Lackey. (*Proc. Inst. Rad. Eng. Australia*, April 1943, Vol. 5, No. 1, pp. 9–15.)

145. Impedance Bridge with D.C. Galvanometer [Drawback of Simple Bridge with Rectifiers in Zero or Auxiliary Branch, that the Rectifiers are working at Min. Sensitivity at Balance, overcome by Auxiliary Biasing Voltage].—E. Mittelmann. (*Sci. Abstracts*, Sec. B, Oct. 1943, Vol. 46, No. 550, p. 181.)

146. Additions to " Measuring Coil Characteristics without an Impedance Bridge " [3487 of 1943]. —H. D. Brailsford. (*Electronics*, June 1943, Vol. 16, No. 6, p. 266.)

147. A Capacitance Brdige for determining the Ratio [within 0.1%] and Phase Angle [within 3 Minutes] of Potential Transformers.—H. W. Bousman & R. L. Ten Broeck. (*Elec. Engineering*, Aug. 1943, Vol. 62, No. 8, Transactions pp. 541–544.)

148. New Methods for the Testing of Potential Transformers [Instrument Transformers]: Differential Methods: I.—W. Hohle. (*Arch. f. Tech. Messen*, May 1943, Part 143, Z33-2, Sheets T61–62.)

149. Correspondence on " Design of Simple Ohmmeters " [3096 of 1943: Analysis of the Accuracies of the Various Decades: Misleading Descriptions on Some Universal Meters: Suggestions for Improved Markings].—P. d'E. Stowell: Hogg. (*Wireless World*, Nov. 1943, Vol. 49, No. 11, pp. 344–345.)

150. An Apparatus for the Measurement of Very Small Local Variations of a Magnetic Field. —C. E. Mulders. (*Physica*, Vol. 9, 1942, p. 853 onwards.)

151. Thyratron-Tube Tester [tests for Shorts, Low Ionising-Potential, Erratic Operation, & Low Emission].—V. P. McKinney. (*Electronics*, July 1943, Vol. 16, No. 7, pp. 128 and 130.)

152. Checking Cables in Aircraft with the Roto-bridge Automatic Production Tester [1938 of 1943].—D. A. Griffin. (*Electronics*, June 1943, Vol. 16, No. 6, pp. 200..206.)

153. Production Speeded [by a Test Fixture for Electrical & Mechanical Testing of Three-Way Signal-Selector Switch: Lamp Indicators instead of Previous Inspection].—(*Gen. Elec. Review*, Aug. 1943, Vol. 46, No. 8, p. 461.)

154. An Equipment for High-Voltage Tests of Measuring Apparatus.—N. N. Ponomarev & N. N. Razumovski. (*Izvestiya Elektroprom. Slab. Toka*, No. 8, 1940, pp. 46–48.)

A description is given of an equipment developed in which the voltage applied to the apparatus under test can be gradually increased to the required value up to 3500 V without altering the shape of the voltage curve, and precautions are taken against possible damage by the spark caused by a local breakdown. The equipment meets the Russian technical regulation that such equipment should have a minimum capacity of 0.5 kVA.

155. High-Tension Testing: Details of New Research Laboratory at Zurich.—Swiss Oerlikon. (*Electrician*, 17th Sept. 1943, Vol. 131, No. 3407, pp. 273–275.)

156. On Testing the Suitability of Apparatus for Use under Severe Climatic Conditions.— S. A. Smirnov. (*Izvestiya Elektroprom. Slab. Toka*, No. 11, 1940. pp. 38–44.)

An illustrated description is given of the following equipment used in a special laboratory for the above tests: (1) Altitude chamber, complete with two vacuum pumps for pressures down to 41 mm, which corresponds to a height of 20 000 m; (2) low-temperature chamber, using liquid oxygen to obtain temperatures down to — 60°C; (3) high-temperature chamber for temperatures up to 100° C; (4) vibration table, which can vibrate

with 30 different amplitudes between 0 and 8 mm at frequencies from 400 to 5000 c/s; and (5) humidity chamber in which humidities up to 95% can be obtained.

157. THE TECHNIQUE OF MATERIALS TESTING: III—ELECTRICAL TESTS (CONTINUED).—W. D. Owen. (*BEAMA Journal*, Sept. 1943, Vol. 50, No. 75, pp. 271–276.) Continued from 3132 of 1943.

158. WAR RADIO COMPONENTS STABILISED [Fixed Paper Condensers, Meters].—(*Electronics*, June 1943, Vol. 16, No. 6, pp. 126–127.)

159. METER PROTECTION [Request (from Signal Corps School) for Arrangement to protect against Overload and damp the Needle's Motion: Editorial Reply].—(*Electronics*, June 1943, Vol. 16, No. 6, pp. 340 and 341.) *See* also L. J. Fohr (Littlefuse, Incorporated: 1945 of 1937), in July issue, No. 7, pp. 188 and 190.

160. TEMPERATURE-COMPENSATION OF INSTRUMENTS [Frequent Failure to realise Seriousness of Ambient-Temperature Errors: Brooks's Compensation Method (660 of 1937) & Usual Commercial Practice both waste Power: Use of Negative-Temperature-Coefficient Resistances: Faus's Resistances containing Tellurium or Cadmium (ref. "2" & Patents): Semiconductors (Pearson's "Thermistors," 1326 of 1941: Tests with "Globar" & Keystone Carbon Resistors): Application to Commercial Diesel-Engine Pyrometer].—J. R. Pattee. (*Electronics*, Aug. 1943, Vol. 16, No. 8, pp. 102–105 and 190..200.) Including Hoffman's suggestion for straightening the resistance/temperature characteristic of a resistor.

161. LESS CRITICAL MATERIALS IN CRITICAL INSTRUMENTS [by Use of Alternate Materials & Adaptation of Designs to use Less Material].—I. F. Kinnard & H. C. Dickinson. (*Elec. Engineering*, Aug. 1943, Vol. 62, No. 8, pp. 344–350.)

162. MULTIVIBRATORS [Mode of Action treated by Mechanical Analogy: Applications].—P. C. Jones. (*Bell Lab. Record*, Sept. 1943, Vol. 22, No. 1, pp. 17–23.)

163. TRANSMITTERS WITH MULTIPLE RETROACTION-CHANNELS [and Their Use as Generators with High Frequency-Constancy: in Transmitter–Receiver Combinations for Measuring & Checking Purposes, etc: a Test Set for Valve & Other Small Capacitances].—Golicke. (*See* 68.)

164. METHOD OF STABILISING THE FREQUENCY OF VALVE OSCILLATORS.—Pungs. (*See* 67.)

165. QUARTZ-CRYSTAL CUTS [Basic Cuts & Recent Modifications (AT to GT and JT Cuts): the "Doughnut" Type with Shear Motion coupled to Flexure in Ring: etc.].—L. A. Elbl. (*Electronics*, July 1943, Vol. 16, No. 7, pp. 110–112 and 252..254.)

166. X-RAY QUARTZ ANALYSIS MACHINE [with Two Goniometers].—Philips Metalix Corporation. (*Electronics*, June 1943, Vol. 16, No. 6, p. 322.)

167. THE USE OF PAINTS AND COLOURED CRAYONS AS TEMPERATURE INDICATORS.—K. Guthmann & others. (*Génie Civil*, 1st June 1943, Vol. 120, No. 11, p. 128: summary only.) *Cf.* Penzig, 2023 of 1942, and back reference.

168. ERRATUM: PROPOSAL FOR THE EXTENSION OF OUR SYSTEM OF MENSURATION [2881 of 1943].—E. C. Bingham. (*Journ. Applied Phys.*, Aug. 1943, Vol. 14, No. 8, p. 436.)

SUBSIDIARY APPARATUS AND MATERIALS

169. COORDINATE RECORDER OF HIGH SENSITIVITY [Modification of Saladin's Two-Galvanometer Optical System, giving Greatly Improved Results: Substitute for Cathode-Ray Oscillograph].—Lueg. (*Zeitschr. V.D.I.*, 12th June 1943, Vol. 87, No. 23/24, p. 374: summary only.)

170. THE ADJUSTMENT OF CONTRAST BETWEEN OSCILLOGRAMS APPEARING SIMULTANEOUSLY ON A CATHODE-RAY OSCILLOGRAPH.—Gordienko. (*Izvestiya Elektroprom. Slab. Toka*, No. 11, 1940, pp. 45–49.)

Oscillograms of several functions, having different amplitudes and frequencies and displayed simultaneously on a cathode-ray oscillograph, may differ greatly in intensity. A brief theoretical discussion is given on the effect of various factors on the brilliancy of the trace, and the following two methods are proposed for regulating the intensity of the individual traces: (a) the duration of the image on the screen can be regulated by adjusting the duration of the "opening" of the corresponding thyratron in the thyratron commutator (which is similar to that described in a previous paper, 2808 of 1943); and (b) the intensity of the ray can be synchronously varied, *i.e.* modulated. Diagrams of the proposed circuits are shown, together with oscillograms so obtained.

171. THREE-TRACE CATHODE-RAY TUBES [Difficulty in obtaining: Invitation to Would-be Purchasers].—Gilson. (*Electronics*, Aug. 1943, Vol. 16, No. 8, p. 280.)

172. SOME UNUSUAL APPLICATIONS OF THE CATHODE-RAY OSCILLOGRAPH [Operating-Time of a Relay: Reverberation Characteristics of a Room].—Patchett. (*Electronic Eng:g*, Oct. 1943, Vol. 16, No. 188, pp. 195–196: to be contd.)

173. CATHODE-RAY OSCILLOGRAPH: THE BRAUN TUBE, PART 3—FLUORESCENT SCREEN [Mechanism: Preparation: Luminous Output & After-Glow: Fatigue: X-Ray Danger].—Bigalke. (*Arch. f. Tech. Messen*, May 1943, Part 143, J834-29, Sheet T60.) A short survey.

174. X-RAY STRUCTURAL INVESTIGATIONS ON ZINC-SULPHIDE–COPPER PHOSPHORS, BY THE POWDER METHOD [Researches supplementing the Work of Becker & Schaper on the Destruction of Phosphorescence, 3110 of 1943 & Back References].—Wecker. (*Ann. der Phys.*, 13th May 1943, Vol. 42, 1942/3, No. 7/8, pp. 561–572.)

175. SURVEY OF LUMINESCENCE [with Tables giving Relative Responses of Various Phosphors to Radiation from Long Ultra-Violet to Alpha Rays, etc.].—Levy & West. (*Electronics*, May 1943, Vol. 16, No. 5, pp. 156 and 158: summary only, from *Endeavour*, Jan. 1943.) *See* also 531 of 1943.

176. THE CHEMICAL AND PHYSICAL PROPERTIES OF LUMINESCENT MATERIALS [Distinctly Alchemical, if not Culinary, Flavour still pervading the Preparation of Phosphors: Luminescence in Inorganic Solids: Activation, Fluxes: Exact Linear Relationship between Emission-Band Peak & Percentage of CdS in ZnS Compounds ("so far no physical theory has been advanced. . . .") : Mechanism of Luminescence: etc.].—Strange. (*Proc. Phys. Soc.*, 1st Sept. 1943, Vol. 55, Part 5, No. 311, pp. 364–371.)

177. FORMATION OF A DIVISION OF ELECTRON AND ION OPTICS.—American Physical Society. (*Journ. Applied Phys.*, Aug. 1943, Vol. 14, No. 8, p. 406.)

178. Recent Developments in the Electron-Supermicroscope [Survey].—von Ardenne. (*T.F.T.*, April 1943, Vol. 32, No. 4, pp. 83–89.)

Including the observation of living materials by the use of the object-shadowing device (3490 & 3595 of 1941, and 1774 of 1942); the extension of resolving power by the use of short-focus lenses (also 1774 [and 515] of 1942) and consideration of the limits of resolution (summarised by Ruska, 140 of 1943); the "impression" technique for surface structure (Mahl, 2065 of 1942: *also* von Ardenne & Kircher, ref. "11"); chemical research with the writer's reaction chamber (1774 of 1942, and 179, below); the importance of "object heating" technique (1774/5 of 1942); direct recording on moving films (a paper to be published in *Zeitschr. f. Phys.* is mentioned, on electron-microcinematography with the "Universal" electron-microscope: Figs. 8–11); fine-ray electron diffraction (3693 of 1942: "for example, with an electron probe of only 1μ diameter, single-crystal diagrams were obtained from a gold-foil preparation"). The writer ends:—"The above review of the developmental work on the supermicroscope during the War shows that progress in this field, now as ever, has been carried out in spite of the conditions of the time practically only in German laboratories."

179. Reaction-Chamber Supermicroscopy with the Universal Electron Microscope [Lens-Fitting containing Object Reaction-Chamber for Continuous Observations of Reactions between a Gas & a Liquid or Solid Object-Substance: Practical Experiences & Results].—von Ardenne. (*Sci. Abstracts*, Sec. B, Aug. 1943, Vol. 46, No. 548, p. 153.)

180. Surface Electron-Microscopy of Glass and Ceramics by the "Impression" Method.—Gölz. (*Zeitschr. f. tech. Phys.*, No. 1, Vol. 24, 1943, p. 8 onwards.) For a correction ("height differences down to 10μ" instead of 10mμ) *see* No. 3, 1943, p. 62: and *cf.* 3118 of 1943.

181. Combined Electron Diffraction and Microscope Apparatus.—Prebus. (*Phys. Review*, 1st/15th June 1943, Vol. 63, No. 11/12, p. 462: notice of *Am. Phys. Soc.* paper.) *Cf.* 3084 of 1942.

182. The Early History of the Electron Microscope [with Extracts from Rüdenberg's U.S. Patents with Priority of May 1931].—Rüdenberg. (*Journ. Applied Phys.*, Aug. 1943, Vol. 14, No. 8, pp. 434–436.) *Cf.* 3115 of 1943.

183. Unique Electron Micrographs: the Electron Microscope discovers the Bacteria of Bacteria.—Luria & Anderson. (*Electronic Eng'g*, July 1943, Vol. 16, No. 185, pp. 61–62.) From a *Proc. Nat. Acad. Sci.* paper.

184. A Vacuum Furnace [for the Heat Treatment of Materials or Parts under Vacuum Conditions].—Ehrenberg & Ansbacher. (*See* 114.)

185. Resistance Heating Grids [Flexible Asbestos Grids for heating Small Chambers (*e.g.* for Quartz Crystals)].—Landis & Gyr, Inc. (*Review Scient. Instr.*, July 1943, Vol. 14, No. 7, p. 226.)

186. Vertical Glass-Sealer with Rotating Fires.—Eisler Engineering. (*Electronics*, June 1943, Vol. 16, No. 6, p. 328.)

187. The Use of Wood's Metal in Vacuum Systems [instead of Usual Greases, for Taper Joints, Special Stopcocks, etc.].—Hughes & Pao. (*Review Scient. Instr.*, Aug. 1943, Vol. 14, No. 8, pp. 254–255.)

188. High-Vacuum Technique and High-Vacuum Pumps [Paper on W. Gaede's Work, in honour of his 65th Birthday].—Justi. (*E.T.Z.*, 3rd June *1943, Vol. 64, No. 21/22, pp. 285–287.*) An Editorial note calls attention to Gaede's 1906 success (not developed further) in generating self-excited oscillations around 1 Mc/s by the canal rays of a mercury-vapour lamp.

189. On the Measurement of Extremely Low Pressures with the McLeod Gauge [Investigation of the "Sticking" Effect in the Capillary Tube and of the Mercury Vapour-Pressure Influence on Measurements at Very Low Pressures: Technique (Pre-Treatment of Capillary, etc.) enabling the "Sticking" Effect to be used to estimate Such Pressures (10^{-8} mm Hg) within 25%].—Haase. (*Zeitschr. f. tech. Phys.*, No. 3, Vol. 24, 1943, pp. 53–55.) For previous work *see* 3119 of 1943.

190. Thyratron-Tube Tester [tests for Shorts, Low Ionising-Potential, Erratic Operation, & Low Emission].—McKinney. (*Electronics*, July 1943, Vol. 16, No. 7, pp. 128 and 130.)

191. Simple Test Set for Mercury-Vapour Rectifiers [Internal Tube Drop (Function of Filament Emission & Load Current, and Increasing with Age) rapidly Measured].—Weiner. (*Electronics*, April 1943, Vol. 16, No. 4, p. 112.)

192. Discussion on Metal Rectifiers and Their Application to Radio and to Measurements [Informal Meeting].—I.E.E. Wireless Section. (*Journ. I.E.E.*, Part III, Sept. 1943, Vol. 90, No. 11, pp. 146–147.)

193. Electrical Rectifiers ["Rectodyne," in Models of Capacity up to 4 kW: incorporating Rugged Dry-Plate Rectifier].—McColpin-Christie Corporation. (*Electronics*, June 1943, Vol. 16, No. 6, p. 325.)

194. The Electrical Conductivity and Isothermal Hall Effect in Cuprous Oxide [from Room Temperature to 700° & 450° C respectively: No Evidence for Intrinsic Conductivity or for Change of Sign of Hall Coefficient: Simple Theory of Semiconduction needs Considerable Extension: General Interpretation of Results].—Feldman. (*Phys. Review*, 1st/15th Aug. 1943, Vol. 64, No. 3/4, pp. 113–118.)

195. A Self-Stabilised High-Voltage Source for Geiger Counters.—Chandrashekhar Aiya. (*Current Science* [Bangalore], Aug. 1943, Vol. 12, No. 8, p. 227.)

Various previous methods of obtaining stabilised high voltages are referred to: in all of them a separate rectifier and a separate stabiliser, bias batteries, etc., are employed. "A self-stabilised high-voltage source is being developed, and its circuit is shown in Fig. 1. The circuit is self-explanatory. By introducing an air-gap in the central leg of the h.v. transformer, some degree of stability is obtained. By adjusting the bias to the grid of the rectifier, the stability is increased. Feeding back the d.c. output current to the primary further improves the stability of the output voltage. The coupling between the plate and grid by a condenser reduces the ripple to an unnoticeable amount and also improves the stability. The primary circuit contains lamp resistances which reduce surges and regulate the output voltage. In such a circuit it is found that a mains-voltage variation of 60 v in a 230 v supply produces a variation in the output voltage of less than

10 v. An output-current change of 10 μA produces no perceptible change in the output voltage. . . ."

196. LOW-CAPACITANCE A.C. POWER SUPPLIES.—Mountjoy & Finnigan. (*Bulletin, Inst. Rad. Eng. Australia*, March 1943, pp. 2–4.) *See* 1246 of 1943.

197. ELECTRONIC VOLTAGE REGULATORS: SIMPLIFIED METHOD OF DESIGN: ESTIMATION OF PERFORMANCE [Basic Circuit: Various Improved Circuits, including the Methods of Lindenhovius & Rinia (817 & 2077 of 1942) and Banerjee (150 of 1943)].—Hogg. (*Wireless World*, Nov. & Dec. 1943, Vol. 49, Nos. 11 & 12, pp. 327–331 & 371–373.)

198. A NEW AUTOMATIC DRIVE FOR REGULATING APPARATUS FOR MAINTAINING CURRENT CONSTANCY [in A.C. or D.C. Circuits: Voltage-Resonance Circuit with Saturated-Iron Choke, controlling Regulating Motor: Sensitivity ±1%].—Blankenburg. (*Elektrot. u. Masch:bau*, 2nd April 1943, Vol. 61, No. 13/14, pp. 143–147.)

199. LETTER ON "ELECTRONIC REGULATORS FOR A.C. GENERATORS" [Benson, 3533 of 1943: calling Attention to Weinland's Regulator (1932 Abstracts, pp. 295 & 420)].—Bradley: Benson. (*Electronics*, June 1943, Vol. 16, No. 6, p. 339.)

200. A NOTE ON A SIMPLE BARRETTER [made from Four Torch-Lamps, sensitised by Careful Aging till Normal Resistance is Nearly Trebled].—El-Sherbini & Yousef. (*Proc. Phys. Soc.*, 1st Sept. 1943, Vol. 55, Part 5, No. 311, pp. 428–429: summary only.)

201. ON THE MECHANISM OF CURRENT CONDUCTION IN THE NERNST "NEEDLE" [Survey of Knowledge of Ionic (Electrolytic) Conduction in Solids, Higher Conductivity of Mixed Oxides, etc.].—Wagner. (*Naturwiss.*, 4th June 1943, Vol. 31, No. 23/24, pp. 265–268.) One of a series of papers in memory of Walther Nernst.

202. ARBOR FOR CERAMIC COIL FORMS [to minimise Breakages during Winding].—General Electric. (*Electronics*, July 1943, Vol. 16, No. 7, p. 136: sketch & caption only.)

203. SOME PHYSICAL PROCEDURES USED IN CERAMIC RESEARCH.—Bole & Loomis. (*Journ. Applied Phys.*, Sept. 1943, Vol. 14, No. 9, pp. 443–450.)

204. CERAMIC INSULATING MATERIALS AT HIGH TEMPERATURES [and Their Testing: New Investigations on Calit, Steatit, Tempa, Condensa, Sipa, & Ardostan Types, etc., show that at 200–600° Many Materials show Ionic Conduction, so that Measurements of Insulation Resistance must be made with Alternating Voltage].—Richter & Weicker. (*E.T.Z.*, 25th Feb. 1943, Vol. 64, No. 7/8, pp. 103–104.)

205. MICA-CAPACITOR ALTERNATES [Metal-Cased Oil Tubulars, Type 38: 0.001 to 0.01 μF].—Aerovox Corporation. (*Electronics*, Aug. 1943, Vol. 16, No. 8, p. 251.)

206. MICA AND ITS SUBSTITUTES.—Dériberé. (*Génie Civil*, 15th May 1943, Vol. 120, No. 10, p. 120: summary only.) *Cf.* 2492 & 3541 of 1943.

207. LOW-EXPANSION GLASS MADE WITH TITANIUM OXIDE.—Nordberg. (*Sci. News Letter*, 21st Aug. 1943, Vol. 44, No. 8, p. 120.) A Corning Glass Works patent.

208. SANDLESS GLASS: NEW OPTICAL GLASS OMITS THE FAMILIAR SILICA [Zinc-Oxide & Cadmium-Oxide Glasses].—Tillyer & Moulton. (*Scient. American*, Aug. 1943, Vol. 169, No. 2, p. 59.)

209. THE MANUFACTURE OF "RESINOX" RESINS AND MOULDING COMPOUNDS.—Monsanto Chemical. (*Sci. Abstracts*, Sec. B, Feb. 1943, Vol. 46, No. 542, p. 40.)

210. POST-WAR PROBLEMS OF THE INDIAN LAC INDUSTRY.—Sen. (*Current Science* [Bangalore], July 1943, Vol. 12, No. 7, pp. 199–202.) With an appendix listing the known uses of lac products.

211. PLASTIC TYPE 41 WITH LOW RESIN CONTENT [not more than 25% by Weight: Similar in Properties to Type S (40–40%)].—(*Zeitschr. V.D.I.*, 12th June 1943, Vol. 87, No. 23/24, p. 358.)

212. NEW NON-CRITICAL PLASTIC FROM REDWOODS ["Shellerite"], *and* CELLULOSE ACETATE PLASTIC MATERIAL ["Durashield"].—(*Electronics*, June 1943, Vol. 16, No. 6, pp. 318 and 319: p. 321.)

213. POLYKOL-INSULATED CABLES [Advantages of Polykol (a Plasticised Polyvinyl Chloride) over Rubber].—Ward & Goldstone, Ltd. (*Electrician*, 22nd Oct. 1943, Vol. 131, No. 3412, p. 407.)

214. NEW VULCANIZABLE PLASTIC ["Plioflex" Rubber Substitute].—(*Sci. News Letter*, 3rd July 1943, Vol. 44, No. 1, p. 4.)

215. MECHANICAL PROPERTIES OF PLASTICS AT NORMAL AND SUB-NORMAL TEMPERATURES.—Oberg & others. (*Sci. Abstracts*, Sec. B, Sept. 1943, Vol. 46, No. 549, p. 172.)

216. ELECTRICAL PROPERTIES OF NEOPRENE: RESULTS OF SOME AMERICAN TESTS.—Yerzley. (*Electrician*, 27th Aug. 1943, Vol. 131, No. 3404, pp. 207–208.)

217. SYNTHETIC RUBBER TO-DAY [Résumé of Many Important Types].—Crowe. (*Scient. American*, Sept. 1943, Vol. 169, No. 3, pp. 115–117.)

218. PROGRESS IN RUBBER CHEMISTRY [Symposium].—(*Sci. Abstracts*, Sec. A, June 1943, Vol. 46, No. 546, p. 128.)

219. RUBBER RESEARCH LABORATORY AT MURRAY HILL.—Malm. (*Bell Lab. Record*, April 1943, Vol. 21, No. 8, pp. 226–232.)

220. WAR RADIO COMPONENTS STABILISED [Fixed Paper Condensers, Meters].—(*Electronics*, June 1943, Vol. 16, No. 6, pp. 126–127.)

221. COPPER-PLATED "CUPAL": A REVIEW OF SOME RESULTS OF NEW INVESTIGATIONS.—Scherle. (*Metallwirtsch.*, Vol. 21, 1942, p. 627 onwards.) *Cf.* 2842 of 1943.

222. ON THE THEORY OF THE MAGNETIC [Polarised Iron-Core] AMPLIFIER.—Buchhold. (*See* 55.)

223. TWO NEW INVAR ALLOYS FOR ELECTRONIC DEVICES ["Carpenter Free-Cut Invar 36" and "Maginvar"].—(*Electronics*, May 1943, Vol. 16, No. 5, p. 116.) *See* also 2512 of 1943.

224. POWDERED IRON CORES [Their Development, Present Use, & Future Possibilities].—Crossley. (*Journ. Applied Phys.*, Sept. 1943, Vol. 14, No. 9, pp. 451–455.)

With a pot-type core the writer has made a 200 μH inductance with $Q = 420$ at 1 Mc/s: the Polydoroff d.f. loop aerial of 2½" diameter gives the same pick-up voltage as a 9" air-core loop, and reduces "antenna effect" and, of course, wind resistance: a "new device" (Fig. 11) will "revolutionise a.f. and r.f. coupling systems: this device provides means for varying coupling from zero to a desired maximum value, and in addition the

phase relationship of the said inductive coupling can be adjusted to be aiding or opposing the electrostatic coupling inherent in the system being coupled."

225. On the "Remanence" of the Magnetostriction of Polycrystalline Iron and Nickel.—Kornetzki. (*Ann. der Phys.*, 21st July 1943, Vol. 43, No. 3, pp. 203–219.)

The writer points out the importance of magnetostriction in the generation of supersonic waves, and the application of the thermodynamically converse effect (of the change in magnetisation by external mechanical forces) to a magneto-elastic pressure pick-up for measuring static or short-period pressures: also, the important rôle played by magnetostriction in connection with the permeability and coercive force of a material, and the information given, by an investigation of magnetostriction, regarding the distribution of the spontaneous magnetisation in the Weiss domains. Hitherto, magnetostrictive remanence—the change of length after the magnetic field has been cut off, referred to the original length—has been dismissed as negligible compared with the much greater remanence of magnetisation: but this is because the measurements were made almost exclusively on short, thick bars or ellipsoids, and often on magnetically hard materials which, as the measured results now reported show, display only slight magnetostrictive remanence. The present investigation deals theoretically with the subject and also experimentally, with tests on long, thin samples having very small demagnetising factors; and it is shown that this type of remanence plays an important rôle in the damping of mechanical oscillations by magneto-mechanical hysteresis. Other implications are discussed briefly. For work by the same writer *see* 212 & 3018 of 1943.

226. Neutron Polarisation and Ferromagnetic Saturation [including a Confirmation of the Halpern–Holstein Theory and a Determination of Microcrystalline Dimensions].—Bloch & others. (*Phys. Review*, 1st/15th Aug. 1943, Vol. 64, No. 3/4, pp. 47–56.)

227. Coercive Force [and Its Two Definitions: Editorial prompted by the Faus & Macintyre Paper referred to in 852 & 898 of 1943].—G. W. O. H. (*Wireless Engineer*, Oct. 1943, Vol. 20, No. 241, pp. 469–472.)

228. A Comparison of the Magnetic Properties of Solid and Powdered Magnetites: with Observations on Coercive Force.—Herroun. (*Proc. Phys. Soc.*, 1st July 1943, Vol. 55, Part 4, No. 310, pp. 338–343.)

229. Effect of Magnetic Viscosity on the Velocity of the Variation of the Magnetisation of Iron.—Telesnin. (*Sci. Abstracts*, Sec. A, Nov. 1942, Vol. 45, No. 539, p. 285.)

230. On the Magnetic Properties of Steel for Radio Apparatus.—Yanus, Shubina, & Druzhinin. (*Izvestiya Elektroprom. Slab. Toka*, No. 8, 1940, pp. 49–56.)

The specific requirements which should be laid down for steel to be used in the manufacture of transformers in radio apparatus are discussed, and the necessity is pointed out for taking account of gapping when there is a relatively strong polarising current. A ballistic circuit (Fig. 2) for testing samples is described, and methods are discussed for the correct estimation of permeability from the experimental results. It is also suggested that instead of demagnetising the samples before testing, they should be magnetised immediately before each test in a field of a definite intensity. Finally, the errors introduced by various types of joints in the magnetic circuit are estimated.

231. Methods for designing A.C. Magnetic Circuits, allowing for Iron Losses.—Sotskov. (*Izvestiya Elektroprom. Slab. Toka*, No. 8, 1940, pp. 56–64.)

Fundamental relationships between the alternating magnetic flux in a closed magnetic circuit, the ampere-turns, and the magnetic constants are derived. Since, however, equations of the 4th and even 6th degree are involved, graphical methods are proposed to simplify calculations.

232. The Application of the Method of Successive Integration to Magnetic Systems Stabilised Magnetically by Partial Demagnetisation.—Razumovski. (*Izvestiya Elektroprom. Slab. Toka*, No. 11, 1940, pp. 56–58.)

Up to the present the design of magnetic systems by the method of successive integration has been used only in the case of systems magnetised after assembly and not subjected to any further operations. In this paper the use of the method is extended to systems which have been stabilised magnetically by partial demagnetisation. To do this it is necessary to determine the characteristic of the magnet corresponding to the instant when it is subjected to the action of the demagnetising field. Methods are indicated for obtaining the characteristic when the system is stabilised (a) by d.c., and (b) by a.c. with a decreasing amplitude. The discussion is illustrated by a numerical example.

233. The Determination of the Transit Time of the Moving Parts of an Electromagnetic Device.—Livshits. (*Izvestiya Elektroprom. Slab. Toka*, No. 11, 1940, pp. 50–55.)

In the first part of the paper methods are indicated for calculating the transit time t_1, ignoring friction. The effects of friction and of counteracting forces, such as those exerted by the springs, are then considered and conditions are established necessary for the oscillatory movement to become aperiodic. The solution of the differential equations involved is discussed and in conclusion the effect of the moving parts on the current through the winding is briefly considered. It is pointed out that under certain conditions this current may even change in sign.

234. A Method for Correlating Duty-Cycle Tests on Solenoids [A.C., and D.C. of Current-Economising Type].—Ryan. (*Elec. Engineering*, Sept. 1943, Vol. 62, No. 9, Transactions pp. 579–581.)

235. The Influencing of Relay Response Times by Biasing.—Mutschke. (*Zeitschr. f. Fernmeldetech.*, Vol. 23, 1942, p. 170 onwards.)

236. Aircraft Contactors [Contacts (Bounce: Welding & Transfer, and the Use of Cadmium Oxide: Wear): Magnets: Mounting & Special Features], *and* Manual Switches for Aircraft.—Russell & Charbonneau: Millermaster. (*Elec. Engineering*, Sept. 1943, Vol. 62, No. 9, Transactions pp. 563–566: pp. 596–598.)

237. Beryllium–Copper improved for Many Uses by New Heat Treatment.—(*Scient. American*, Sept. 1943, Vol. 169, No. 3, p. 114.) For recent papers on this material *see* 3165 of 1943.

238. Beryllium–Copper and Its Applications: Reply to Comments, etc.—Crossley & Foster. (*Journ. of Scient. Instr.*, Aug. 1943, Vol. 20, No. 8, p. 134.) *See* 1287 of 1943 (where the second author's name was omitted).

239. THE PRACTICAL SERVICING AND TESTING OF VIBRATORS.—(*Bulletin, Inst. Rad. Eng. Australia*, March 1943, pp. 7–8.) Concluded from the February issue.

240. DEVICE TO ENSURE THAT SEVERAL TOGGLE-SWITCHES ARE CLOSED IN A FIXED ORDER & OPENED IN REVERSE ORDER.—Bescherer & Fritts. (*Bell Lab. Record*, Sept. 1943, Vol. 22, No. 1, pp. 14 and 26–27.)

241. PRECISION TURN COUNTER [for Laboratory or Factory Use: Magnetic Principle].—General Electric. (*Scient. American*, Aug. 1943, Vol. 169, No. 2, p. 86.) For coils of up to 11 110 turns, at the rate of 80–100 coils per hour.

242. APPARATUS FOR MARKING METAL BY AN ETCHING PROCESS [using Ordinary Waxed-Paper Stencil].—Griffin & Tatlock, Ltd. (*Journ. of Scient. Instr.*, Sept. 1943, Vol. 20, No. 9, p. 149.)

STATIONS, DESIGN AND OPERATION

243. SYNCHRONISING CONTROLS OF HIGH ACCURACY AND RELIABILITY.—Barkow & Lechner. (*E.T.Z.*, 25th Feb. 1943, Vol. 64, No. 7/8, pp. 108–109.) Another summary of the report dealt with in 2099 of 1943.

244. METHOD FOR THE TRANSMISSION OF INFORMATION WITH THE USE OF A NARROW FREQUENCY-BAND.—Fischer. (*Hochf:tech. u. Elek:akus.*, April 1943, Vol. 61, No. 4, p. 125.)

D.R.P.726 973. "Of the given frequency band at the transmitting end (for example 300, 600, 900, and 2100 c/s), each frequency is raised or lowered by the same percentage for all frequencies (say 10% or less) without appreciable alteration to the length of the signal. From the resulting distorted band (*e.g.* 330, 660, 990, and 2310 c/s) and the original band, with the help of modulating and filtering arrangements, a frequency-band is derived which contains only the differences of the various corresponding frequencies (*e.g.* 30, 60, 90, and 210 c/s), and this band is transmitted. At the receiving end the narrow band is again extended. The distortion and restitution of the frequencies can be carried out by means of an iconoscope with recording and reproducing beams moving at different speeds."

245. THE ABSORPTION PEAKS OF THE TRANSMISSION EQUIVALENT OF OVERHEAD LINES [Extension of Kaden & Kaufmann's Work (4240 of 1938) to Arbitrarily Transposed Lines used for Carrier-Frequency Transmission].—Ellenberger. (*T.F.T.*, April 1943, Vol. 32, No. 4, pp. 75–83.)

246. QUALITY AT A DISTANCE [and How to ensure It in the Future: Wired Broadcasting will Never Satisfy the Vast Numbers of Wireless Experts returning to Civil Life: etc.).—"Diallist." (*Wireless World*, Nov. 1943, Vol. 49, No. 11, pp. 348–349.)

247. WIRED WIRELESS IN CIVILIAN DEFENCE: THE PRINCE GEORGE'S COUNTY (MARYLAND) EMERGENCY COMMUNICATIONS SYSTEM, *and* CARRIER-CURRENT COUPLING CIRCUITS FOR CIVILIAN DEFENCE.—Wightman & Lyon. (*QST*, Aug. 1943, Vol. 27, No. 8, pp. 14–17: *Electronics*, Aug. 1943, Vol. 16, No. 8, pp. 144..150.)

248. "WALKIE-TALKIES" IN CIVILIAN DEFENCE, AND AT SEA.—(*Journ. Applied Phys.*, Sept. 1943, Vol. 14, No. 9, p. 468.)

249. TRAIN COMMUNICATION [Its Applications: Previously Proposed Methods: the Union Train Communication System using Single-Sideband Carrier-Telephone Method with Pre-Emphasis].—Grondahl & Bossart. (*Elec. Engineering*, July 1943, Vol. 62, No. 7, Transactions pp. 493–500.)

250. RADIO TELEPHONE ON GOODS TRAINS [for Communication between Engine Crews & Guards: L.N.E.R. Tests].—Rediffusion, Ltd. (*Electrician*, 22nd Oct. 1943, Vol. 131, No. 3412, p. 397.)

251. SIGNALLING EQUIPMENT FOR USE IN MINES.—Colberg. (*Zeitschr. f. Fernmeldetech.*, Vol. 23, 1942, p. 183 onwards.)

252. "ELEKTRISCHE FERNMELDEEINRICHTUNGEN IM GRUBENBETRIEB" [Communication in Mines: Book Review].—Busch & Gassmann. (*E.T.Z.*, 17th June 1943, Vol. 64, No. 23/24, p. 337.)

MISCELLANEOUS

253. COMPARISON OF THE TRANSFORM AND CLASSICAL METHODS.—Hovey: Lyon. (*See* 41.)

254. MATRIX ALGEBRA AND THE SOLUTION OF ELECTRICAL NETWORK PROBLEMS. — Simmonds. (*Electronic Eng:g*, Sept. & Oct. 1943, Vol. 16, Nos. 187 & 188, pp. 160–161 & 212–213.)

255. CHART FOR DETERMINING THE SQUARE ROOT OF A COMPLEX NUMBER [in Transmission-Line & Filter Calculations]. — Nisle. (*Electronics*, Aug. 1943, Vol. 16, No. 8, pp. 127 and 128.)

256. DESIGNING SPECIAL SLIDE RULES [for Cases where Numerous Approximate Calculations are made with the Same Formula: Detailed Instructions].—Odell. (*Electronics*, May 1943, Vol. 16, No. 5, p. 172: summary only.)

257. ERRATUM: PROPOSAL FOR THE EXTENSION OF OUR SYSTEM OF MENSURATION [2881 of 1943].—Bingham. (*Journ. Applied Phys.*, Aug. 1943, Vol. 14, No. 8, p. 436.)

258. "THE TECHNIQUE OF RADIO DESIGN" [Book Review].—Zepler. (*Wireless World*, Nov. 1943, Vol. 49, No. 11, p. 331.)

259. "FUNDAMENTAL PRINCIPLES OF ELECTRIC AND MAGNETIC CIRCUITS" [Book Review].—Fish. (*See* 39.)

260. REVIEWS OF FOUR ELEMENTARY BOOKS ON RADIO, ELECTRICITY, SHOP PRACTICE, AND MATHEMATICS FOR SKILLED WORKERS.—(*Electronics*, June 1943, Vol. 16, No. 6, pp. 347 and 348.) *See* also pp. 352 and 353.

261. CONFERENCE ON TEACHING ULTRA-HIGH-FREQUENCY PHENOMENA.—(*Elec. Engineering*, Aug. 1943, Vol. 62, No. 8, p. 373.)

262. COLLEGE COURSES IN ELECTRONICS ["One of the Weak Links in Most Curricula": Suggestions].—Lutz. (*Electronics*, July 1943, Vol. 16, No. 7, pp. 226 and 227.)

263. TRAINING TECHNICAL LEADERS FOR WAR: ARMY SPECIALISED TRAINING PROGRAMME AND NAVY COLLEGE TRAINING PROGRAMME. — Beukema: Barker. (*Elec. Engineering*, March 1943, Vol. 62, No. 3, pp. 89–93: pp. 93–95.)

264. NEW LABORATORY TECHNIQUES EXPEDITE TRAINING IN ELECTRONICS [Pictorial Demonstration Boards

at Cruft Laboratory, Harvard University].—(*Electronics*, June 1943, Vol. 16, No. 6, pp. 90–93.)

265. TRAINING GIRLS TO MAKE TUBES [General Electric Company's System].—Yoder. (*Electronics*, Aug. 1943, Vol. 16, No. 8, pp. 106–107 and 228, 230.)

266. MOVIES AND SLIDEFILMS SPEED WARTIME TRAINING OF TECHNICIANS.—Metcalfe. (*Electronics*, July 1943, Vol. 16, No. 7, pp. 98–99.)

267. TRAINING ELECTRICAL CRAFTSMEN: RESULTS OF SELECTION SCHOOL: SCHOOLMASTERS' COOPERATION.—Brush Elec. Eng. (*Electrician*, 1st Oct. 1943, Vol. 131, No. 3409, p. 335.)

268. RESEARCH AND THE WAR EFFORT [and the Relationship between Scientists, Engineers, & the Armed Services: the Work of the O.S.R.D. and Other Agencies].—Bush. (*Elec. Engineering*, March 1943, Vol. 62, No. 3, pp. 96–102.) By the Director of the O.S.R.D.

269. THE WORK OF THE WAR POLICY COMMITTEE OF THE AMERICAN INSTITUTE OF PHYSICS, *and* A PROGRAMME OF DEVELOPMENT FOR PHYSICS.—Klopsteg: American Institute of Physics. (*Review Scient. Instr.*, Aug. 1943, Vol. 14, No. 8, pp. 236–241: pp. 241–247.)

270. THE SCIENCE MOBILISATION BILL: REPLY TO CRITICISMS, AND EXPOSITION OF THE FIVE PRIMARY NEEDS ON WHICH THE BILL IS BASED.—Kilgore. (*Science*, 13th Aug. 1943, Vol. 98, No. 2537, pp. 151–152.) *See* Egloff, 2891 of 1943: for the Resolution of the I.R.E. Board of Directors see *Proc. I.R.E.*, Aug. 1943, p. 453, and for criticisms, section by section, from the Am. Assoc. for the Advancement of Science see *Science*, 6th Aug. 1943, pp. 135–137.

271. MOBILISATION OF SCIENTIFIC RESOURCES: III [Description of the Leading Wartime Civilian Scientific Organisations, including National Academy of Sciences, National Research Council, National Roster of Specialised & Scientific Personnel, National Inventors' Council, etc.].—(*Journ. Applied Phys.*, Aug. 1943, Vol. 14, No. 8, pp. 373–405.)

272. THE WAR AND POST-WAR INTEGRATION OF RESEARCH ACTIVITIES IN THE UNITED STATES.—Heindel. (*Nature*, 21st Aug. 1943, Vol. 152, No. 3851, p. 212: summary only.) The author is director of the American Library of the Office of War Information.

273. WARTIME RADIO PRODUCTION [Sketch of the Work of the Radio-Radar Division of the War Production Board].—Ellis. (*Proc. I.R.E.*, July 1943, Vol. 31, No. 7, pp. 379–380.)

274. RADIO STANDARDS GO TO WAR [Work of the War Committee on Radio, American Standards Association].—Westman. (*Proc. I.R.E.*, July 1943, Vol. 31, No. 7, pp. 381–384.)

275. THE ENGINEER'S POSITION IN THE MAN-POWER PROGRAM.—Miles. (*Proc. I.R.E.*, Sept. 1943, Vol. 31, No. 9, pp. 514–517.) From the offices of the National Roster of Scientific & Specialised Personnel.

276. WARTIME RADIO-AND-ELECTRONIC ENGINEERING PAPERS [Editorial, with Communication from Chief Signal Officer of the Army of U.S.A.].—(*Proc. I.R.E.*, Feb. 1943, Vol. 31, No. 2, p. 45.)

277. ESMWT [Engineering, Science, & Management Defence Training] TRAINING AT RUTGERS UNIVERSITY.—DeSoto. (*QST*, Sept. 1943, Vol. 27, No. 9, pp. 38–43 and 88..98.)

278. RADIO INSTRUCTION IN THE ROYAL CANADIAN AIR FORCE [No. 1 Wireless School, Montreal].—Patrick. (*QST*, Aug. 1943, Vol. 27, No. 8, pp. 9–13 and 106.)

279. ELECTRONICS BIBLIOGRAPHY FOR WAR TRAINING.—(*Electronics*, May & June 1943, Vol. 16, Nos. 5 & 6, pp. 109–111 & 128–130.) Including some forthcoming volumes.

280. THE RADIO ENGINEER IN PSYCHOLOGICAL WARFARE [Short-Wave Broadcasting Situation in U.S.A. at Outbreak of War compared with That in England, Germany, Japan, etc: Present Situation, and the Work of the O.W.I. & the Coordinator of Inter-American Affairs: Radiophoto Service & Its Special Value for China: etc.].—Corderman. (*Proc. I.R.E.*, Sept. 1943, Vol. 31, No. 9, pp. 510–514.)

281. THE RADIO ENGINEER IN THE NAVY.—Holden. (*Proc. I.R.E.*, Sept. 1943, Vol. 31, No. 9, pp. 517–519.)

The job is " to get there fustest with the mostest . . . Despite all the reasons why it can't be done, it may be that in radio fields the methods of Henry Kaiser to do the job in a novel, quicker way are needed to save time".

282. RECENT DEVELOPMENTS IN MILITARY RADIO COMMUNICATION [including " Blind Broadcasting " of News Photographs, Glass Strings for Kite Aerials (3390 of 1943, and pp. 245, 246), Thermostatically Stabilised Wavemeters (3475 of 1943), etc.].—(*Electronics*, July 1943, Vol. 16, No. 7, p. 212.)

283. RADIO-ROBOT BATTLE [at Army Air Force School: Electric Cars controlled by Radioed Instructions go through Manoeuvres of Raiding & Defending Squadrons].—(*Electronics*, Aug. 1943, Vol. 16, No. 8, p. 97: photographs & captions only.)

284. RADIO AND RADAR AT WAR [Photographs & Captions only: including the Bendix Automatic S.O.S. Transmitter for Airmen forced down at Sea].—(*Electronics*, Aug. 1943, Vol. 16, No. 8, pp. 118 and 119.)

285. TROPIC-BOUND REPLACEMENT PARTS [for Radio & Radar Instruments] ARE SEALED IN PLASTIC CONTAINERS.—(*Electronics*, Aug. 1943, Vol. 16, No. 8, p. 214.)

286. COMMUNICATIONS SECRECY [Cable Secrecy is Questioned].—Hutchens. (*Electronics*, June 1943, Vol. 16, No. 6, pp. 294 and 296.) " The United States might be better off if it cut its own submarine cables . . ." Summary, from RCA Communications' *Relay*.

287. INVASION COMMUNICATIONS: THE JOBS OF THE SIGNAL CORPS ARE MANY AND VARIED.—Sigerson. (*Scient. American*, Aug. 1943, Vol. 169, No. 2, pp. 53–55.)

288. SOME PROBLEMS IN WHICH THE ARMY IS INTERESTED.—National Inventors Council. (*Proc. I.R.E.*, Sept. 1943, Vol. 31, No. 9, p. 524.)

289. CONSERVING VITAL MATERIALS FOR WAR: PART II.—Horn. (*Gen. Elec. Review*, Aug. 1943, Vol. 46, No. 8, pp. 449–454.) Concluded from 3205 of 1943.

290. NEW AGENCY WILL SUPPLY LABORATORIES WITH HARD-TO-FIND PARTS [Formation of Electronic Research Supply Agency and Its Duties].—Despres. (*Electronics*, June 1943, Vol. 16, No. 6, pp. 284.. 288.) *See* also 2552 of 1943.

291. "EDUCATION AND TRAINING FOR ENGINEERS" [Review of Report based on Paper read by Fleming & Subsequent Discussions (1848 & 2181 of 1942)]. —I.E.E: Fleming & others. (*Nature*, 31st July 1943, Vol. 152, No. 3848, pp. 137–138.)

292. RESEARCH IN PHYSICS IN THE POST-WAR PERIOD [including Comparisons with Great Britain and U.S.S.R.].—Harnwell. (*Review Scient. Instr.*, Aug. 1943, Vol. 14, No. 8, pp. 231–236.)

293. RESEARCH AND PLANNING [Leading Article on Recent Speeches, Addresses & Letters].—(*Nature*, 7th Aug. 1943, Vol 152, No. 3849, pp. 141–144.)

294. THE INTERNATIONAL ORGANISATION OF RESEARCH [Leading Article].—(*Engineering*, 27th Aug. 1943, Vol. 156, No. 4050, pp. 171–172.)

295. "SCIENCE AND THE FUTURE" [No. 7 of the Series of Pamphlets entitled "The British Way": Review].—Trueman. (*Journ. of Scient. Instr.*, Sept. 1943, Vol. 20, No. 9, p. 152.)

296. "INDUSTRIAL RESEARCH: WHAT IT MEANS TO INDUSTRY" [Review of Pamphlet].—Hartley. (*Electrician*, 10th Sept. 1943, Vol. 131, No. 3406, p. 245.) *See* also p. 261.

297. CURRENT TRENDS IN THE AMERICAN PHYSICAL SOCIETY [Agitation for Greater Participation by Physicists in Industry in the Society's Affairs].—(*Journ. Applied Phys.*, Sept. 1943, Vol. 14, No. 9, pp. 437–442.)

298. POST-WAR PLANNING PROBLEMS [in the Wireless & Electronics Industry].—(*Electronics*, May 1943, Vol. 16, No. 5, pp. 72–73 and 136, 138.)

299. RESEARCH AND PLANNING [Denunciation of Views tending to Destroy the Ideal of Scientific Truth pursued & upheld for Its Own Sake].—Polanyi. (*Nature*, 21st Aug. 1943, Vol. 152, No. 3851, pp. 217–218.)

300. SUGGESTION SCHEMES [in Industrial Organisations]. —Bond. (*Electrician*, 23rd July 1943, Vol. 131, No. 3399, p. 83.) From the Chairman, Fort Dunlop Suggestions Committee.

301. THE PLACE OF SCIENTISTS IN THE COMMUNITY [Reply to Packard–Findlay–Bragg Letter (*see* End of 2267 of 1943) from the Association of Scientific Workers].—Wooster. (*Wireless Engineer*, Sept. 1943, Vol. 20, No. 240, pp. 436–437.) And in other journals around the same date.

302. LEADERSHIP IN A DYNAMIC SOCIETY [Editorial on the Views of P. W. Bridgman, Herbert Morrison, W. W. Hutt, & C. I. Barnard].—(*Nature*, 24th July 1943, Vol. 152, No. 3847, pp. 85–87.)

303. FEDERATION OF THE PROFESSIONS.—Crampton. (*Engineer*, 30th July 1943, Vol. 176, No. 4568, pp. 88–89.) *See* also leading article, pp. 90–91; under the heading "Federation of Engineering Societies."

304. CORRESPONDENCE CONCERNING PROPOSED CONSTITUTIONAL AMENDMENTS TO I.R.E: AN IMPORTANT ASPECT OVERLOOKED.—Terman. (*Proc. I.R.E.*, July 1943, Vol. 31, No. 7, p. 388.) *See* also 2889 of 1943.

305. HENLEY'S EDUCATION SCHEME.—Dunsheath. (*Wireless World*, Nov. 1943, Vol. 49, p. 334.)

306. FUTURE OF TECHNICAL COLLEGES [Criticism of Recommendation in Institute of Physics' Report on Education & Training of Physicists].—Barrer & Andrews. (*Nature*, 17th July 1943, Vol. 152, No. 2846, p. 80.)

307. EXTENDING EDUCATIONAL OPPORTUNITIES: BRIT. I.R.E. ANNUAL REPORT.—(*Wireless World*, Sept. 1943, Vol. 49, No. 9, p. 273.)

308. EDUCATION AFTER THE WAR [Meeting of Association of University Professors & Lecturers of the Allied Countries, and an International University Conference].—(*Nature*, 21st Aug. 1943, Vol. 152, No. 3851, pp. 221–222: including comments on an international language.)

309. OTTO JESPERSEN AND AN INTERNATIONAL AUXILIARY LANGUAGE [Review of an Ido Society Publication]. —Jacob. (*Nature*, 18th Sept. 1943, Vol. 152, No. 3855, p. 324.) For Lauwerys' remarks on Esperanto, Basic English, and Hogben's Interglossa, *see* issue for 25th Sept. 1943, No. 3856, pp. 340–341.

310. THE FREE GERMAN INSTITUTE OF SCIENCE AND LEARNING [Letter from British Scientists appealing for Its Support].—(*Electrician*, 20th Aug. 1943, Vol. 131, No. 3403, p. 184.)

311. SCIENCE UNDER FASCISM AND DEMOCRACY [Conference of Association of Scientific Workers, West Midland Area: Personal Impressions].—(*Nature* 11th Sept. 1943, Vol. 152, No. 3854, pp. 306–307.)

312. INTERNATIONALISM IN SCIENCE [American Philosophical Society Broadcast].—Darrow. (*Science*, 6th Aug. 1943, Vol. 98, No. 2536, pp. 122–123.) ". . . if you walk through the galleries of physics you do not find the masterpieces labelled 'French School' or 'Dutch School' or 'Italian School.' There is just one school of physics, and from its inception it has been the school of all civilised nations."

313. SCIENCE AND NATIONALITY [Leading Article].— (*Nature*, 4th Sept. 1943, Vol. 152, No. 3853, pp. 253–255.)

314. SCIENTIFIC INFORMATION [Address to A.S.L.I.B.].— Crowther. (*Engineering*, 24th Sept. 1943, Vol. 156, No. 4054, p. 252: summary only.)

"There should be a Library of International Science in every country, with a staff of trained scientists and linguists. Working in close cooperation with such a library there should be a Central Translating Bureau. All important foreign papers should be immediately translated when they are received, and the translation made available to subscribers." At present, "apart from the abstracts which are published by some of the sections of the Department of Scientific and Industrial Research, it is difficult to think of any regular scientific bibliographic service operated by the Government." *See* also *Engineer*, 1st Oct. 1943, pp. 272–273, and Editorial, p. 266.

315. THE MERITS OF ABSTRACTING JOURNALS [with Special Reference to *Biological Abstracts*, but with General Application also].—Kirby. (*Science*, 23rd July 1943, Vol. 98, No. 2534, p. 84.)

316. OVERLAPPING ABSTRACT SERVICES.—Ridsdale. (*Nature*, 21st Aug. 1943, Vol. 152, No. 3851, p. 217.) The present letter deals only with an inquiry by the Society of Dyers and Colourists.

317. TRANSLITERATION OF RUSSIAN NAMES [Continuation of Correspondence: the Usefulness of the Library of Congress Rules].—Nichols: Strong. (*Science*, 6th Aug. 1943, Vol. 98, No. 2536, pp. 132–133.)

318. "RADIONICS" AND "ELECTRONICS" [Further Correspondence on 2897 of 1943].—Bennett. (*QST*, Aug. 1943, Vol. 27, No. 8, p. 68.) *See* also p. 95, where Zenith Radio define Radionics as subdivided into Electronics, Radar, and Radio. For an Editorial (quoting A.P.H.'s tests: are you intelligible? are you pleasing? are you legitimate? are you needed?) see *Electronic Eng:g*, Aug. 1943, p. 95.)

319. NEW WORDS IN SCIENCE [Letter from Science Editor of *College Standard Dictionary:* Information wanted on Origin, etc., of Word "Radionics": Need for a "More Intelligent & Comprehensive Treatment" of Language of Science].—Ward. (*Science*, 20th Aug. 1943, Vol. 98, No. 2538, pp. 174–175.)

320. POST-WAR CIVILIAN-AVIATION RADIO PROSPECTS.—Ricketts. (*Electronics*, Aug. 1943, Vol. 16, No. 8, pp. 86–89 and 276.)

321. INTERNATIONAL TELECOMMUNICATIONS: POST-WAR RADIO DEVELOPMENTS [including the Future of Television: Inaugural Address, President I.E.E.]. —Angwin. (*Wireless World*, Nov. 1943, Vol. 49, No. 11, p. 339: summary only.)

322. ELECTRIC COMMUNICATIONS: THE PAST AND PRESENT ILLUMINATE THE FUTURE: A SUGGESTIVE INTERPRETATION.—Espenschied. (*Proc. I.R.E.*, Aug. 1943, Vol. 31, No. 8, pp. 395–402.)

"Altogether, the trends toward new electronic instrumentalities, the higher frequencies, and wave propagation more sharply demarked in space, spell enlarged opportunities and new horizons": a paper intended to stimulate thought.

323. THE ENGINEER'S PLACE IN THE POST-WAR PICTURE [and the Development of the Industrial Market for Electronic Applications].—Egert. (*Electronics*, July 1943, Vol. 16, No. 7, pp. 86–87 and 156.)

324. WALL STREET WATCHES ELECTRONICS [Survey of Reports by Financial Firms, N.Y. Institute of Finance Lecture Series, & *Financial World* Article]. —(*Electronics*, July 1943, Vol. 16, No. 7, pp. 223 ..225.) *See* also August issue, No. 8, pp. 208..214.

325. NEW ELECTRONIC CONSULTING GROUP [to guide Industrial Electronic Work]. — Westinghouse. (*Electronics*, Aug. 1943, Vol. 16, No. 8, pp. 216 and 218.)

326. RADIO TECHNICAL PLANNING BOARD [to plan Post-War Services & Products] TO BE INAUGURATED SEPTEMBER 15TH.—I.R.E. & R.M.A. (*Elec. Engineering*, Sept. 1943, Vol. 62, No. 9, p. 427.)

327. THE GEOPHYSICIST AS A FORECASTER [Problems of Great Economic Importance amenable to Present Technique or Some Modification].—Weaver. (*See* 16.)

328. UTILITY OF THE ELECTRIC METHODS IN GEOPHYSICAL EXPLORATION [Theoretical Possibilities and Physical Background: Full Utility only attainable by Departure from Traditional Electric Methods: Outline of Procedure based on the $\lambda/4$ Criterion (of the "Wiping Out" of an Interface Effect)].—Evjen. (*Geophysics*, April 1943, Vol. 8, No. 2, pp. 146–156.)

With regard to the neglect of the theory of alternating currents in the ground, the writer remarks: "the electric properties of the ground have not been sufficiently well known to warrant extended calculations. For instance, the dielectric constant of the ground may, under certain conditions similar to those existing in electrolytic condensers, become very great so that this quantity cannot be neglected even at very low frequencies. Field results and laboratory tests, not yet published, indicate that values of the dielectric constant as high as 10^{11} may sometimes occur. With such values our concepts would have to be radically changed . . ."

329. SOME EFFECTS OF GEOLOGIC STRUCTURE [notably Contacts between Rocks of Different Composition, especially Fault Contacts] ON RADIO RECEPTION.—Howell. (*See* 81.)

330. THE MUTUAL IMPEDANCE OF COLLINEAR GROUNDED WIRES.—West. (*Geophysics*, April 1943, Vol. 8, No. 2, pp. 157–164.)

"The formula of R. M. Foster (1932 Abstracts, p. 114, r-h col. [and p. 641, l-h col.]) for the mutual impedance of grounded wires lying on the surface of the earth has been evaluated for the case where the wires are grounded at points which are collinear and equally spaced upon the surface of a homogeneous earth. Curves are given showing mutual impedance and phase shift as functions of resistivity and frequency." *Cf.* Wolf, 2691 of 1943 (single grounded wire).

331. ELECTRONIC APPARATUS FOR VIBRATION TESTING [of Turbine Wheels].—Fehr & Shabtach. (*Electronics*, June 1943, Vol. 16, No. 6, pp. 94–96.)

332. PRESSURE OF EXPLODING GUNPOWDER IS RECORDED WITH OSCILLOGRAPH [Oscillograph & Associated Equipment].—DuMont Company. (*Electronics*, Aug. 1943, Vol. 16, No. 8, pp. 186 and 188.)

333. TEMPERATURE-COMPENSATION OF INSTRUMENTS [and Application to Diesel-Engine Pyrometer].—Pattee. (*See* 160.)

334. NEW PRESSURE AND DETONATION PICK-UPS [for the Very High Temperatures in Gas Engines, etc.].—Electro-Products Laboratories. (*Journ. Applied Phys.*, April 1943, Vol. 14, No. 4, p. 201.)

335. ROLLER-PRESSURE MEASUREMENT WITH THE HELP OF AN ELECTRICAL LENGTH-MEASURING INSTRUMENT [the Eltas Gauge].—Emicke. (*Zeitschr. V.D.I.*, 1st May 1943, Vol. 87, No. 17/18, pp. 265–266: long summary.)

336. EXPERIMENTAL DETAILS FOR A PRECISION HIGH-TEMPERATURE CONTROL UTILISING THE HULL CIRCUIT [Galvanometer/Photocell/Thyratron Combination: Temperatures of 600° regulated within $\pm$ 0.05° C.].—Waring & Robison. (*Review Scient. Instr.*, May 1943, Vol. 14, No. 5, pp. 143–146.) *See* Hull, 1929 Abstracts, p. 512 (and not as stated in ref. "2").

337. A THYRATON THERMAL RELAY [for 20°–30° Temperature Control within 0.001° C by Combination of Heater & Fan].—Rittenberg & Sucher. (*Review Scient. Instr.*, Feb. 1943, Vol. 14, No. 2, p. 51.)

338. UNITIZED ELECTRONIC CELLS [Receivers, Remote-Control Units, Transmitters, Alarm Systems, etc.].—Harvey Machine. (*Review Scient. Instr.*, Aug. 1943, Vol. 14, No. 8, p. 257.) *See* 2714 of 1943.

339. THE DESIGN CALCULATION OF CONTINUOUS LINEAR CONTROL SYSTEMS [such as Speed Regulation on the Leonard System with Vibrator Control].—

Rosenhamer. (*Arch. f. Elektrot.*, 31st Dec. 1942, Vol. 36, No. 12, pp. 693–715.)

340. VARIABLE-SPEED DRIVE [" Mot-O-Trol ", giving Close Speed Regulation (20 : 1 Range) for D.C. Motors operating from an A.C. Source].—Westinghouse. (*Review Scient. Instr.*, June 1943, Vol. 14, No. 6, p. 189.) *See* also *Electronics*, June 1943, p. 314.

341. ELECTRONIC CONTROL ON DRILL PRESS [Field of Usefulness greatly Increased by Thy-mo-Trol Drive].—General Electric. (*Electronics*, Aug. 1943, Vol. 16, No. 8, p. 154.) *See* also 342, below.

342. BALANCING 50-TON MARINE GEARS [by Thy-mo-Trol Electronic Control (2582 of 1943)].—General Electric. (*Electronics*, July 1943, Vol. 16, No. 7, p. 132.)

343. ELECTRONIC CONTROL OF D.C. MOTORS: PARTS I, II, AND III.—Moyer. (*Electronics*, May, June, & July 1943, Vol. 16, Nos. 5, 6, & 7, pp. 98–103 and 215..217, 119–125, & 118–122.) From the Industrial Control Engineering Department, General Electric Company.

344. ELECTRONIC EXCITER FOR A.C. GENERATORS [" an All-Electronic Combination Voltage Regulator & Exciter for Small Engine-Driven A.C. Generators, worthy of Consideration as a Packaged Item for Post-War Manufacture "].—Benson & Heidbrak. (*Electronics*, Aug. 1943, Vol. 16, No. 8, pp. 112–114 and 261.) Developed from the regulator dealt with in 3533 of 1943.

345. ELECTRONIC CONTROL: MAINTENANCE AND TROUBLE-SHOOTING TIPS.—Cockrell. (*Gen. Elec. Review*, Sept. 1943, Vol. 46, No. 9, pp' 489–492.)

346. " RADIO CONTROL FOR MODEL AIRCRAFT " [Book Notice].—Hunt. (*Wireless World*, Nov. 1943, Vol. 49, No. 11, p. 345.)

347. AMPLIFICATION OF DIRECT-CURRENT IMPULSES, WITH SUPPRESSION OF AMPLIFIER NOISE [of Special Importance for the Working of Sensitive Relays, etc.].—Köhler. (*See* 48.)

348. POWER OUTPUT OF A.C.-OPERATED AMPLIFIERS [for Many Industrial Applications].—Schwarzmann. (*See* 47.)

349. THE PRODUCT-RATIO METER [851 of 1943] IN ITS VARIOUS CIRCUIT-FORMS.—Lorenz. (*E.T.Z.*, 20th May 1943, Vol. 64, No. 19/20, pp. 258–261.)

350. ELECTRONIC INTERVAL-MEASURER.—General Electric. (*Electronics*, Aug. 1943, Vol. 16, No. 8, p. 152.) *See* 3617 of 1943.

351. EIGHT-TRACE RECORDING TIMER [" Metron," Types 4A & B: Intervals from 1/60th Second to 12 Minutes recorded on Electrically Sensitive Paper].—Metron Instrument. (*Electronics*, June 1943, Vol. 16, No. 6, p. 316.)

352. DETECTING SMALL MECHANICAL MOVEMENTS [as small as a Millionth of an Inch, by converting Them into Capacitance Changes around 0.01 $\mu\mu$F: Improved Circuit nullifying Variations in Oscillator & Cable Characteristics: Pick-Up for Blood-Pressure Investigations].—Frommer. (*Electronics*, July 1943, Vol. 16, No. 6, pp. 104–105.)

353. A NEW MEASURING DEVICE FOR SLOW AND RAPID CHANGES IN LENGTH [the " Ring " Pick-Up (Resistance-Variation Principle): a Few Rings, varying in Diameter from 25 to 100 mm, cover the Range 10^{-3} to 10 mm].—Theis. (*Arch. f. Tech. Messen*, May 1943, Part 143, V1121-2, Sheets T51–52.)

354. MAGNETIC COMPARATOR CHECKS HARDNESS OF AXLE SHAFTS [after Heat Treatment].—(*Electronics*, June 1943, Vol. 16, No. 6, pp. 214 and 216.)

Successfully used over 15 years. " The complete absence of electronic tubes in the unit emphasises the fact that simple mechanical or electrical methods should not be overlooked by electronic engineers when confronted with industrial problems."

355. MAGNETIC CONTROL SWITCH [for Contact-less Control without Capacity-Change or Other Electronic Devices, when there is Ample Actuating Power: Automatic Weighing & Other Applications].—Fuchs. (*Electronics*, July 1943, Vol. 16, No. 7, pp. 196..200.)

356. A FAST CLOCK SWITCH FOR AUTOMATIC CONTROL CIRCUITS [giving Accurately Timed Periodic Momentary Contacts by Metal Wheel (on End of Arm rotated by 1 r.p.h. Clock-Shaft) rolling over Pairs of Closely Spaced Contacts].—Yeater. (*Review Scient. Instr.*, May 1943, Vol. 14, No. 5, pp. 145–147.)

357. AN ELECTRONIC CIRCUIT TO CONTROL INTENSITY AND TIMING OF POWER FOR SPOT WELDING [Combination of Regenerative D.C. Amplifier (acting as Controlled Square-Wave Generator) and a Biased Multivibrator: Possible Application to Other Electronic Control Problems].—Nottingham. (*Review Scient. Instr.*, June 1943. Vol. 14, No. 6, pp. 161–170.)

358. THE DEVELOPMENT AND PRESENT POSITION OF DISTANT-CONTROL TECHNIQUE [in Electricity Supply Systems].—Henning. (*E.T.Z.*, 6th May 1943, Vol. 64, No. 17/18, pp. 235–240.)

359. RADIO HELPS TO MAINTAIN A CONTINUOUS POWER SUPPLY [Carrier-Current System for Automatic Location & Control of Trouble on High-Voltage Systems].—(*Elec. Engineering*, May 1943, Vol. 62, No. 5, pp. 223–224.)

360. TRANSPOSITIONS IN CARRIER-FREQUENCY OVERHEAD LINES [Suggested Construction with Much Smaller Expenditure in Material].—Machens. (*T.F.T.*, Nov. 1943, Vol. 31, No. 11, pp. 298–299.)

361. THE " SPIRAL-4 " CARRIER SYSTEM [3 Telephone & 4 Telegraph Circuits over Single Cable of 4 Spiralling Wires].—Western Electric. (*Elec. Engineering*, May 1943, Vol. 62, No. 5, p. 223: paragraph only.)

362. SYMPOSIUM ON THE RADIO-FREQUENCY HEATING OF PLASTICS.—(*Electronics*, June 1943, Vol. 16, No. 6, pp. 194..200.)

363. ELECTRONICS' BRIGHTEST STAR [Article on High-Frequency Heating of Metals, Plastics, Foodstuffs (Dehydration), Lumber].—(*Scient. American*, Sept. 1943, Vol. 169, No. 3, pp. 103–105.)

364. HEATING WOOD WITH RADIO-FREQUENCY POWER [Theory, Factors determining Applicability, Data for Calculation of Power, etc.], *and* HEATRONIC MOULDING [of Plastics].—Taylor: Meharg. (*Sci. Abstracts*, Sec. B., Sept. 1943, Vol. 46, No. 549, p. 164: p. 164.) For another summary of Meharg's paper see *Electronic Eng:g*, July 1943, Vol. 16, No. 185, p. 84.

365. High-Frequency Heating in Plywood Manufacture.—Aero Research, Ltd. (*Engineering*, 6th Aug. 1943, Vol. 156, No. 4047, pp. 116–117.) From *Bulletin No. 6*, June 1943. *Cf.* 2572 of 1943 and back references.

366. Electric Glue Heating: Development of Scheme for Speeding Output.—Aero Research, Ltd. (*Electrician*, 24th Sept. 1943, Vol. 131, No. 3408, pp. 297–299.) *See* also 365, above.

367. Glue "Welding": Spots are Quickly Set by Radio-Thermics.—Laucks, Inc. (*Scient. American*, Aug. 1943, Vol. 169, No. 2, pp. 58–59.) *See* also 2572 of 1943.

368. High-Frequency Heating [Photographs & Captions illustrating Four Commercial Applications].—(*Electronics*, April 1943, Vol. 16, No. 4, p. 108.)

369. Spark-Gap Circuits used in Induction-Heating Units.—Lepel High-Frequency. (*Electronics*, July 1943, Vol. 16, No. 7, pp. 126 and 128.)

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374. Chemical Analysis with a Cathode-Ray Oscilloscope.—Jones. (*Electronics*, April 1943, Vol. 16, No. 4, pp. 154..158.) Long summary of the paper, under a different title, referred to in 1574 of 1943.

375. A Self-Stabilised High-Voltage Source for Geiger Counters.—Chandrashekhar Aiya. (*See* 195.)

376. Tracing Radioactively-Labelled Particles through the Body with a Geiger-Müller Counter.—Pommerenke & Hahn. (*Electronics*, July 1943, Vol. 16, No. 7, pp. 200 and 202.) *Cf.* Clark & others, 3625 of 1943.

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378. Distribution of Light Intensity within a Scattering Medium.—Newton. (*See* 21.)

379. Properties of Low-Reflection Films produced by the Action of Hydrofluoric-Acid Vapour.—Nicoll & Williams. (*See* 140.)

380. Light-Actuated Mercury Switch [primarily for Protection against Failure in Oil Burners: "Visaflame" Bulb with Bimetallic Coils, eliminating Photocell Device].—Mercoid Corporation. (*Electronics*, June 1943, Vol. 16, No. 6, pp. 260 and 262).

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388. Portable Photoelectric Colorimeter detects Alcohol in Breath [at Time of Accident or Arrest].—Greenberg. (*Electronics*, June 1943, Vol. 16, No. 6, pp. 222 and 224: summary only.)

389. Colorimeter for Continuously Flowing Liquid [for Continuous Control of Chemical Processes].—Photovolt Corporation. (*Scient. American*, Aug. 1943, Vol. 169, No. 2, pp. 85–86.)

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